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(51) INT CL^5
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A5R REH RHXT

(56) Documents cited
WO 90/00419 A1

(58) Field of search
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INT CL^5 A61N 1/40 1/44 2/00 5/06
Online database: WPI

(54) **Pulsed energy stimulator device**

(57) The device 6 stimulates an individual's skin by producing pulsed electrical 12, 14, magnetic 46, 48 and light 16 energy fields on the area to be treated through a transparent electrical insulating shield 10 and simultaneously passing charged ions 40 over the area. A sequence of frequencies and intensities for the light is described. This has beneficial cosmetic and therapeutic effects, such as promoting hair growth.

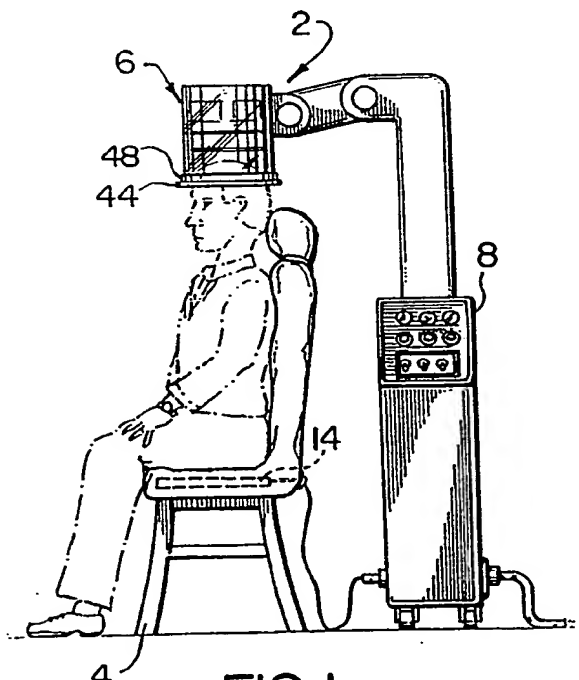

FIG.1

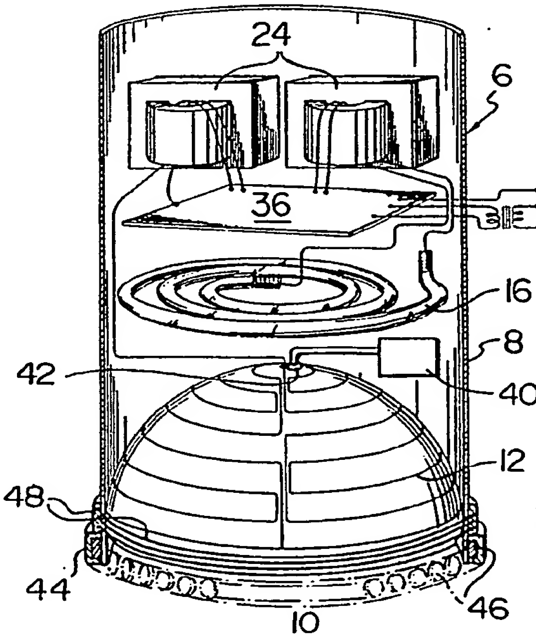

FIG.2

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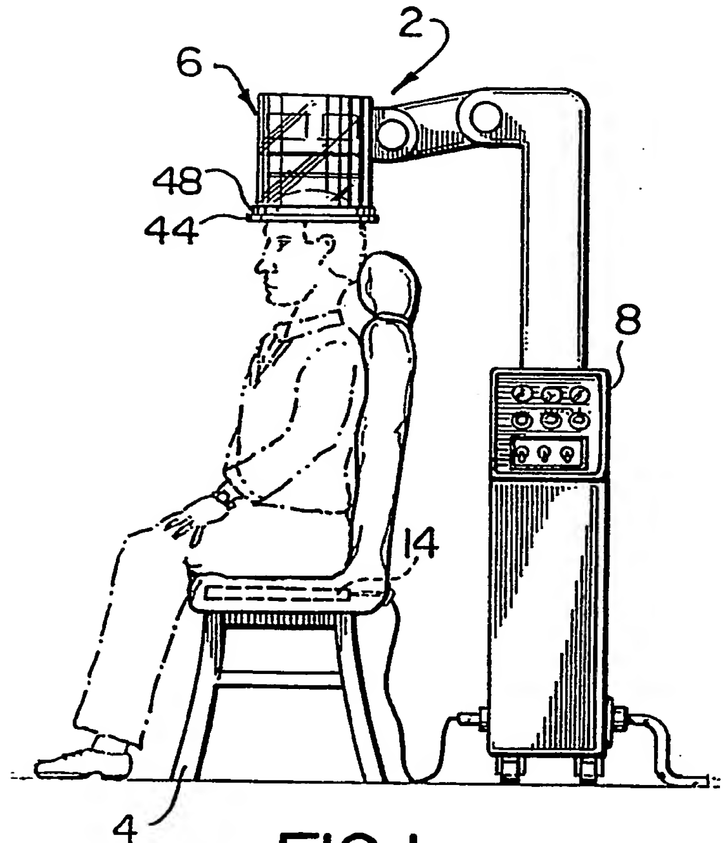


FIG.1

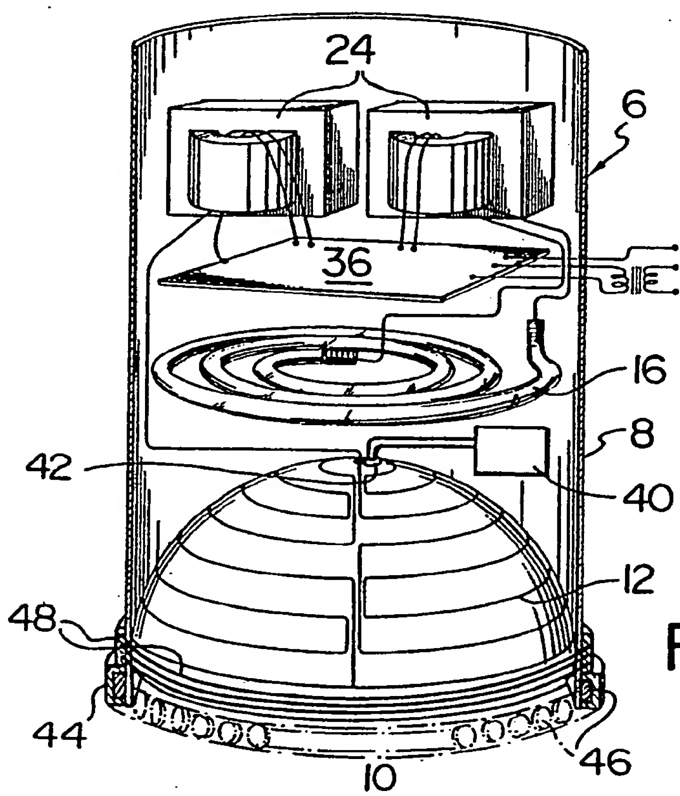
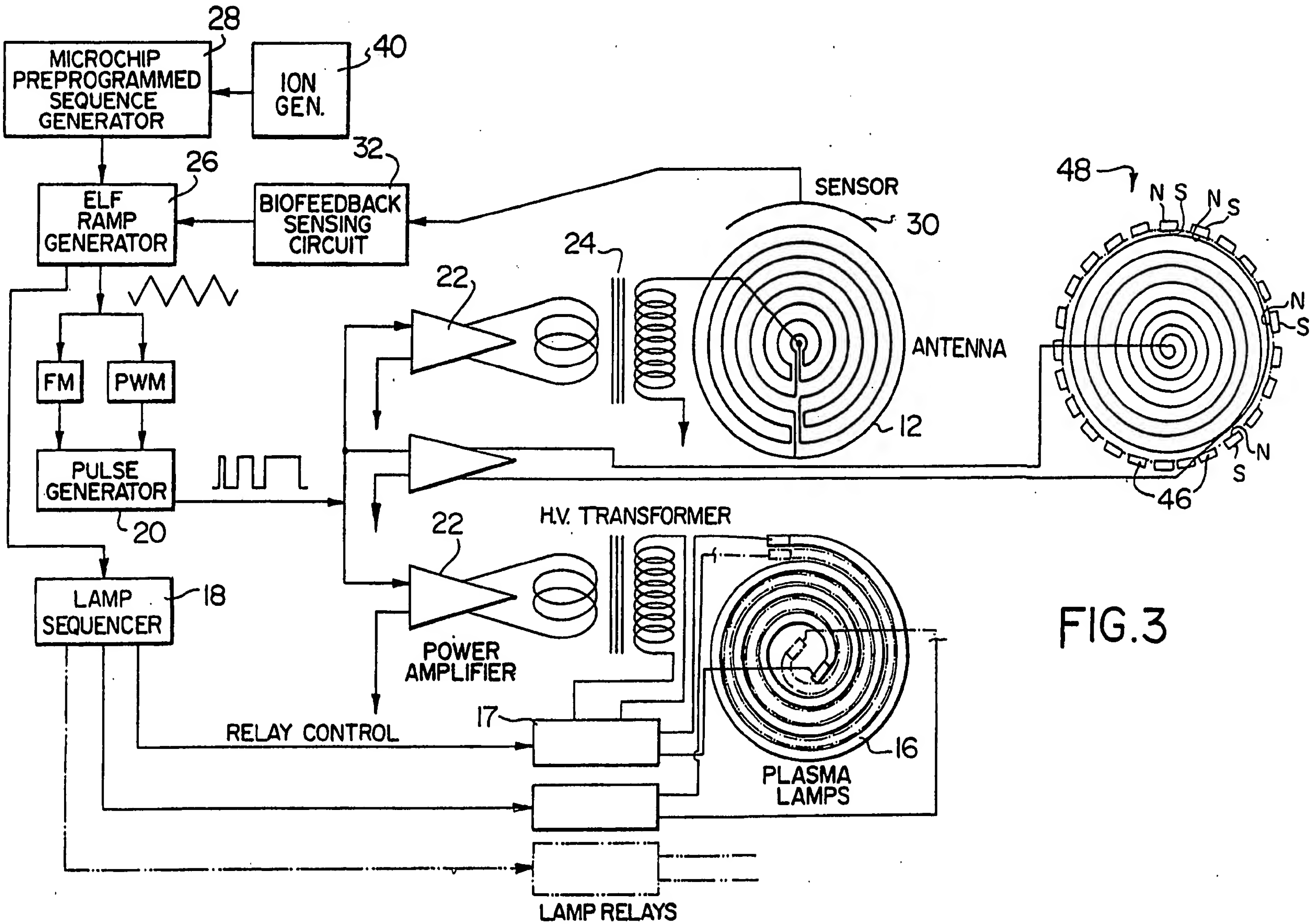


FIG.2



MICROCHIP PREPROGRAMMED SEQUENCE GENERATOR
28
ION GEN.
40
ELF RAMP GENERATOR
26
BIOFEEDBACK SENSING CIRCUIT
32
SENSOR
30
24
22
ANTENNA
12
48
N S
N S
N
S
N
S
46
FM
PWM
PULSE GENERATOR
20
H.V. TRANSFORMER
22
LAMP SEQUENCER
18
POWER AMPLIFIER
17
RELAY CONTROL
16
PLASMA LAMPS
LAMP RELAYS

FIG.3

TITLE OF THE INVENTION

PULSED ENERGY STIMULATOR DEVICE

FIELD OF THE INVENTION

The present invention relates to a device for stimulation of an individual's skin for beneficial cosmetic or therapeutic purposes. More particularly the device of the present invention uses light, electrical and magnetic energy and charged ions to produce this stimulation.

It has been well established by bio-medical scientists that wounded bone and soft body tissues respond well to various kinds of energy stimulation (magnetism, electric fields, light, vibration, ultrasound). Despite the considerable scientific literature on the subject however it is still unclear how such stimulation works. Certainly the electrical fields alter the ability of cell membranes to allow charged ions (especially sodium, potassium, calcium and chlorides) to pass through. Additionally, it is known that cell membranes are examples of liquid crystals whose helical protein molecules become realigned (orthorotated) by an electric field.

In the case of hair follicle cells, in the July - August 1990 issue of The International Journal of Dermatology, at pages 446 to 450, a paper by Stuart Maddin, Peter Bell and John James describes a controlled study which demonstrated the positive biological effect On hair regrowth of a pulsed electrical field administered according to a regularized treatment scheduled over thirty-six weeks. The rationale of that phenomenon was unclear to the authors, but they speculated that the hair regrowth was due to an electrophysiological effect on the quiescent hair follicles, similar to that documented by others with respect to bone fracture and soft tissue repair enhancement. Their apparatus comprised a hood containing electrical output

plates connected to electronic circuitry and a rechargeable 12 volt battery within a lower stand.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a device for stimulating an area of an individual's skin, the device comprising a low frequency field electrical field generation means, a permanent magnet magnetic field generation means, a magnetic field generation means, a charged ion generating means and a light generation means. The light generation means delivers light diffused over the entire area of the skin to be stimulated. The ion generation means delivers charged ions to be blown over that area of the skin. An antenna means fits over the area of the skin to be stimulated, the antenna means electronically associated with the electrical field generation means to cause that area to act as the plate of a capacitor to deliver electrical energy to that area of the skin. Pulse generation means are electronically associated with the electrical and magnetic field generation means and light generation means so that the electrical and magnetic fields and light are generated synchronously or alternately in low frequency pulses. A transparent electrical insulating means is positioned to separate the antenna and other means from direct contact with the area of skin to be stimulated, the electrical insulating means having dielectric capacitive properties.

In a preferred embodiment of the present invention, adapted to slow the deterioration of hair follicles and to begin new hair growth on an individual's scalp, the antenna means is of hemispherical concave shape to fit over the individual's scalp. The pulse generation means during operation drives a high voltage transformer which in turn supplies the antenna so that an electric field on the individuals scalp is such as to be measurable as a voltage through a load of ten kilo-ohms to ground having a maximum peak value of 120 volts, and a minimum

value of 50 volts. As well the light generation means comprises a plurality of plasma lamps of different colour, the plasma lamps being driven by the single generator of pulse wave form, with a relay switching each lamp on in predetermined sequence.

While the device according to the present invention is particularly well adapted to cause hair follicles to slow their deterioration and to begin new hair growth on an individual's scalp, other possible applications of the present invention in its broadest sense are envisaged as follows:

1) Healing of superficial skin wounds, inflammations, ulcers and dermatoses;
2) Healing of various diseases of peripheral blood vessels;
3) Facilitating healing of rheumatoid arthritis;
4) Alleviation of symptoms of migraine;
5) Reducing generalized body pain;
6) Facilitating withdrawal and rehabilitation in addiction to drugs and alcohol;
7) Assisting the body's immune system response in resisting the damaging effects of the AIDS virus; and
8) Alleviating symptoms of psychological depression and some forms of schizophrenia.

It is an object of the present invention particularly to provide an improved device which will effectively stimulate an individual's skin for the purpose of causing hair follicles to slow their deterioration and to begin new hair growth.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the invention will become apparent upon reading the following detailed description and upon referring to the drawings in which:

FIGURE 1 is a perspective view of an arrangement of the device in accordance with the present invention specifically adapted to treat an individual's scalp for stimulating hair follicles to produce reduced hair loss and increased hair growth, incorporating a seat for the individual during treatment;

FIGURE 2 on the second page of drawings is a schematic elevation view, in partial section, of the upper portion of the device of Figure 1; and

FIGURE 3 is a block diagram of the electrical and other components of the device of FIGURE 1.

While the invention will be described in conjunction with an example embodiment, it will be understood that it is not intended to limit the invention to such embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

In the drawings similar features have been given similar reference numerals. Turning to the drawings, there is illustrated in Figure 1 a device 2 in accordance with the present invention, specifically arranged for stimulating the hair root and follicle cells on an individual's scalp. The individual is seated on a chair 4, over which a hood arrangement 6, which will be described in more detail hereinafter, is positioned, with a control panel 8 governing the operation

of the components of hood 6.

As can be seen in Figure 2, hood 6 comprises a cylindrical plastic case 8 within which is positioned, at the lower end, a dielectric transparent hemisphere 10, intended to be positioned over the individual's scalp during treatment (FIGURE 1). On top of the dielectric hemisphere, mounted on the convex inner surface thereof is a wire loop or mesh antenna 12 preferably having from 7 to 50 concentric circular loops each interconnected to the other loops in a Mobius circuit, as illustrated, with wiring such that current through adjacent turns travels in opposite directions. In this way there is cancellation of hertzian radiation and magnification of the scalar energy (thought to have greater healing effect than conventional electro-magnetic (Hertzian) waves). By mounting antenna loops 12 on the convex inner surface of the hemispherical dielectric, the individual scalp is separated from direct contact with any electrical conductors. In this fashion the patient's scalp forms the receiving plate of a capacitor. A grounding conductive pad 14 (FIGURE 1) built into the seat portion of chair 4 further increases the efficiency of this capacitive energy transfer.

It is intended that the intensity of the electric field on the subject's side (concave side) of the glass dielectric will be such as to be measurable as a voltage through a load of 10 kilo-ohms to ground having a maximum peak value of 120 volts, a minimum of 50 volts and preferably 100 volts.

The dielectric hemisphere 10 is made of a transparent non-flammable material having high energy insulation properties and a high dielectric constant in the order of 5 to 8. The dielectric hemisphere is intended as a barrier which serves the purposes of:

1) Diffusing and spreading the electric field;

2) Acting as a high-pass filter by allowing only high frequency wave forms thus reducing the possibility of 60 Hz energy being radiated to the subject;

3) Ensuring complete insulation and isolation of the individual being treated from any electrical conductors whatsoever.

The antenna wire can be of any conductive metal wire or mesh or metallic paint but more effectively radiates scalar waves if made of brass.

Above antenna wires 12 within plastic hood 6 above dielectric hemisphere 10 is positioned a plurality of plasma lamps 16. Plasma lamps 16 act as a photostimulator when supplied by a source of pulsed high voltage energy at correct frequencies. Each plasma lamp 16 is a tube filled with a mixture of gasses at low pressure. The lamp is electrically pulsed, as will be described in more detail hereinafter, synchronously or alternately with electric field pulses passed through antenna wires 12 to provide an effect which is similar to treatment of skin by soft laser, a procedure commonly used in physiotherapy clinics today. The plasma lamps are controlled by relays 17 and lamp sequencer 18 as illustrated.

Several specially constructed plasma lamps may be used, depending on the phase of a treatment for an individual. For example, for the first 10 sessions a green lamp of maximum wave length λ = 570 nm and minimum λ = 500 nm and preferably 525 nm may be used, for the next 10 sessions a blue lamp of maximum λ = 490 nm and a minimum λ = 460 nm and preferably λ = 475 nm may be used and for the next 10 sessions a violet lamp of maximum λ = 450 nm and minimum λ = 400 nm and preferably λ = 425 nm may be used. For some subjects, treatment may consist of applying two or three colours sequentially during each session. All lamps have an instantaneous power ranging from 50 watts at the highest frequency to 120 watts at the lowest repetition rate.

In addition, as can be seen in Figure 3, device 2 is provided with a single generator of pulse wave form 20 which drives two power amplifiers 22 and high voltage transformers 24 which in turn supply sub-audio and audio frequency energy to antenna 12 and plasma lamp 16.

The wave form is a stream of repetitive pulses whose inter-pulse interval and pulse width are both modulated up and down by an extra-low frequency (ELF) ramp generator 26. At the low end, the pulse width can be a maximum of 10 milliseconds (ms), a minimum of 1 ms and preferably 5 ms, with an interval between pulses of a maximum of 10 seconds, a minimum of 0.5 seconds and preferably 3 seconds. These turn out to be the optimum value to elicit the acupuncture endorphin release response.

At the high end, the pulse width can be a maximum of 0.3 ms, a minimum of 0.1 ms and preferably 0.2 ms, with an inter-pulse interval having a maximum value of 10 ms, a minimum of 1 ms and preferably 6 ms, which corresponds to a frequency of 166.6 Hz. This wide range of pulse width modulation and frequency modulation elicits several beneficial endorphin, cortisol and neurological effects known to promote widespread healing and regeneration of body organs and emotional states in addition to local effects on hair follicles.

As the pulses pass through the transformer 23 and coiled antenna 12, various resonances are introduced by virtue of the inductances and capacitances thereof. By this mechanism, multiple waves having discrete predetermined higher audio frequencies are emitted by the antenna.

The ELF ramp generator 26 has a rate and range determined not only by the pre-designed circuit components and preprogrammed microchip sequence generator 28. It also responds to changes in load parameters by virtue of a signal fed back from sensor 30 at the antenna, through bio-feedback sensing circuit 32 to further modulate the ELF generator 26.

When the load is heavier, i.e. lower resistance, this indicates analogously with the Galvanic Skin Response (G.S.R.) an increased state of anxiety or psychological tension in the subject. There is then fed back to the ELF generator 26 a signal which keeps the pulse frequency more at the higher end (which is known to have more beneficial effects on anxiety and depression). In this way, the ongoing bio-electrical status of the scalp tissue has a modifying effect such that the optimum frequency range is provided through biofeedback.

In construction, bio-feedback sensing circuit 32, ELF ramp generator 26 micro chip programmed sequenced generator 28 and pulse generator 20 may be incorporated in circuit board 36 (Figure 2) as illustrated.

Also within case 8 or associated therewith is an ion generation source 40 by which a stream of air is blown through the high voltage antenna chamber and exits via an orifice 42 at the apex of hood 6. Both positively and negatively charged air ions and a small amount of ozone (less than .01 parts per million) are thus blown over the scalp of the client.

Finally, magnetic fields are generated for the device 2 as follows. Firstly, a ring 44 of small magnets 46 with opposite polar orientation as illustrated (Figure 3) is attached to hood 6 just beneath the antenna and encircles the scalp thus generating a static magnetic field. Secondly, a coil of insulated wire 48 having a number of turns is attached over the same area where the magnets are attached. A low voltage, high current pulsed wave form is passed through this coil thus generating a pulsed electro-magnetic field encircling the scalp.

In operation, pulse generator 20 produces pulses of electric and light energy emanating through the transparent dielectric hemisphere 10 which separates the patient from antenna 12. The patient's scalp forms the other plate of a capacitor. In this way ionizable molecules are forcibly pushed through cell membrane channels in the scalp, increasing the likelihood of them remaining open.

The physiological mechanism is thought to be as follows: the abrupt turning on and off of the electrical stimulus at the antenna 12 causes alternate polarizing and depolarizing of the root and follicle cells stimulating the production of DNA and new protein synthesis while also stimulating mechanical contraction of the arrector pili muscle at the base of each follicle. As previously indicated, the lamp is electrically pulsed synchronously with the electric field pulses to provide an effect similar to treatment of skin by soft laser.

Thus there has been provided in accordance with the invention a device for stimulation of an individual's skin for beneficial cosmetic or therapeutic purposes that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the invention.

CLAIMS:

1. A device for stimulating an area of an individual's skin, the device comprising:

(a) a low frequency electrical field generation means;

(b) a permanent magnetic field generation means;

(c) an induction coil magnetic field generation means;

(d) light generation means to deliver diffused light energy over the entire area of the skin to be stimulated;

(e) charged ion generation means to deliver charged ions to be blown over that area of the skin;

(f) antenna means to fit over that area of the skin, the antenna means electronically associated with the electrical field generation means to cause that area to act as a plate of a capacitor to deliver electrical energy to that area of the skin;

(g) pulse generation means electronically associated with the electrical and magnetic field generation means and light generation means so that the electrical and magnetic fields and light are generated synchronously or alternately in low frequency pulses; and

(h) transparent electrical insulating means positioned to separate said other means from direct contact with the area of skin to be stimulated, the electrical insulating means having dielectrical passative properties.

2. A device according to claim 1 adapted to stimulate root and follicle cells of an individual's scalp, the antenna means being of hemispherical concave shape to fit over the individual's scalp.

3. A device according to claim 2 wherein said electrical insulating means is of glass construction having high electrical insulation properties and a dielectric constant in the range of 5 to 8.

4. A device according to claim 2 wherein the pulse generation means during operation drives a high voltage transformer which in turn supplies the antenna so that an electric field on the treatment side of the antenna is such as to be measurable as a pulsed voltage through a load of ten kilo-ohms to ground having a maximum peak value of 120 volts, and a minimum value of 50 volts.

5. A device according to claim 4 wherein the measurable voltage is 100 volts.

6. A device according to claim 4 wherein the light generation means is a photostimulator supplied by a source of pulsed high voltage energy at predetermined frequencies.

7. A device according to claim 6 wherein the photostimulator is a plurality of plasma lamps of different colours, the plasma lamps being driven by the single generator of pulse wave form with a relay to switch each lamp on in predetermined sequence.

8. A device according to claim 7 wherein during operation selected ones of the plasma lamps are electrically pulsed synchronously with the voltage transformer.

9. A device according to claim 7 wherein the plasma lamps are adapted to operate at a power in the range of from about 50 watts to about 120 watts and generates light of wave length in the range of from about 400 nm to about 570 nm.

10. A device according to claim 7 wherein the plasma lamps are adapted to operate at a power in the range of from about 50 watts to about 120 watts and generates light of wave length in the range of from about 400 nm to about 570 nm and wherein the measurable voltage on the treatment side of the antenna is 100 volts.

11. A device according to claim 7 wherein the pulse wave form generator is adapted to produce a stream of repetitive pulses whose inter-pulse interval and pulse width are modulated up and down by an extra low frequency ramp generator.

12. A device according to claim 11 wherein the pulse width at the low end of light and electrical energy is in the range of about 1 to about 10 milliseconds with an interval between pulses of between about .05 seconds and about 10 seconds, and at the high end a pulse width of between .1 milliseconds and about .3 milliseconds and an interval between pulses of between about 1 milliseconds and 10 milliseconds.

13. A device according to claim 12 wherein the pulse width is about 5 milliseconds with an interval between pulses of about 3 seconds, at the low end of the light and electrical energy provided, and a pulse width of about .2 milliseconds and an interval between pulses of about 6 milliseconds at the high energy end.

14. A device according to claim 10 wherein the pulse wave form generator is adapted to produce a stream of repetitive pulses whose interval and pulse width are modulated up and down by an extra low frequency ramp generator.

15. A device according to claim 14 wherein the pulse width at the low end of light and electrical energy is in the range of about 1 to about 10 milliseconds with an interval between pulses of between about .05 seconds and about 10 seconds, and at the high end a pulse width of between .1 milliseconds and about .3 milliseconds and an interval between pulses of between about 1 milliseconds and 10 milliseconds.

16. A device according to claim 15 wherein the pulse width is about 5 milliseconds with an interval between pulses of about 3 seconds, at the low end of the light and electrical energy provided, and a pulse width of about .2 milliseconds and an interval between pulses of about 6 milliseconds at the high energy end.

17. A device according to claim 11 further comprising a signal feedback means from the antenna electrically associated with the ramp generator and means to alter the rate and range of pulses generated thereby in accordance with signals received from said signal feedback means.

18. A device according to claim 7 wherein the plasma lamps are tubes filled with a mixture of gases at low pressure and electrically pulsed synchronously with the electric field pulses to provide an effect similar to soft laser treatment, the lamps each having an instantaneous power ranging from about 50 watts at the highest frequency to about 120 watts at the lowest frequency.

19. A device according to claim 2 wherein the antenna means comprises a wire loop having a plurality of concentric circles each interconnected to the other circles in a Mobius circuit and arranged so that current through adjacent loops travels in opposite directions whereby Hertzian radiation is canceled.

20. A device according to claim 19 wherein the antenna loops are mounted on the convex inner surface of the hemispherical dielectric which separates the individual's scalp from direct contact with electrical conductor, whereby the individual's scalp forms the receiving plate of a capacitor.

21. A device according to claim 20 wherein a seat means is provided for the individual to be seated during operation of the device and wherein a grounding conductive pad is built into the seat means to further increase the efficiency of capacitive energy transfer to the individual's scalp.

22. A device as claimed in claim 1, substantially as described herein with reference to and as illustrated by any one of the examples shown in the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9225139.6

Relevant Technical fields

(i) UK Cl (Edition L) A5R (RHXT)

(ii) Int Cl (Edition 5) A61N (1/40 1/44 2/00 5/06)

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

Search Examiner

PAUL NICHOLLS

Date of Search

9 FEBRUARY 1993

Documents considered relevant following a search in respect of claims 1-22

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	WO 90/00419 A1 (HENRY AND BERARD) whole document	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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(31) 0009491 (32) 17.04.2000

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United Kingdom

(51) INT CL^7
A61N 5/06

(52) UK CL (Edition S)
A5R REHR

(56) Documents Cited
EP 0266038 A WO 99/19024 A WO 98/43704 A
WO 01/14012 A WO 00/15296 A US 5616140 A

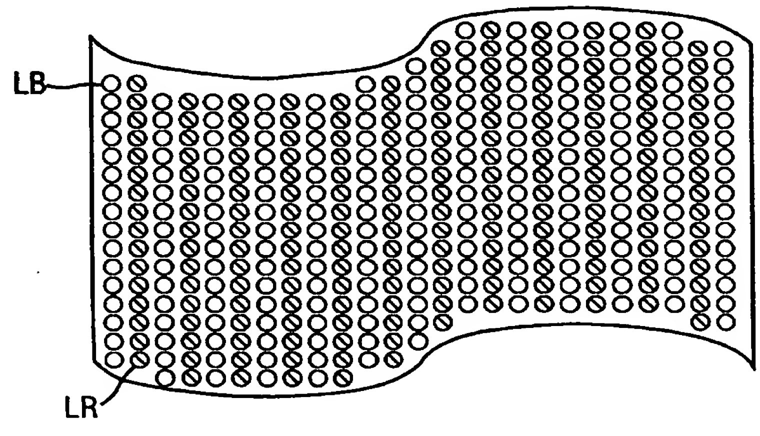
(58) Field of Search
UK CL (Edition S) A5R REHR
INT CL^7 A61N 5/06
ONLINE: EPODOC, WPI, JAPIO

(54) Abstract Title
Therapeutic light source and method

(57) A therapeutic light source, for example for photodynamic therapy (PDT), comprises comprising an array of preferably independently switchable red and blue light-emitting diodes L_R, L_B, mounted on a flexible backing.

Other arrangements of non-planar arrays of LEDs are also claimed, both for external and internal use as well as light sources comprising LEDs having specific emission wavelengths.

FIG. 26



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

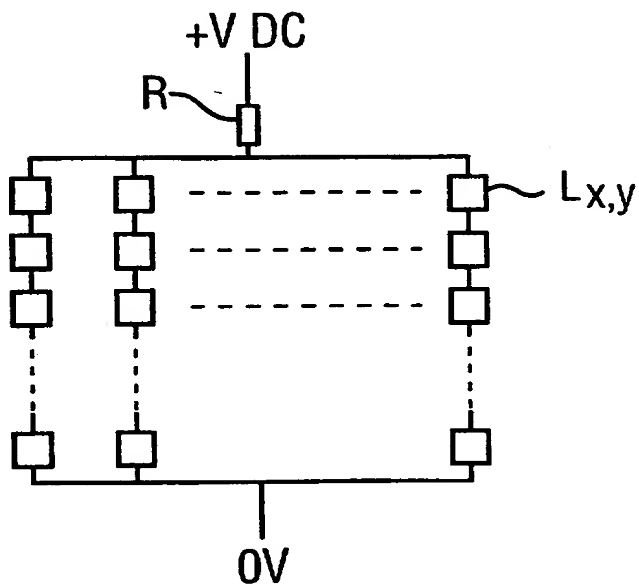


FIG. 5

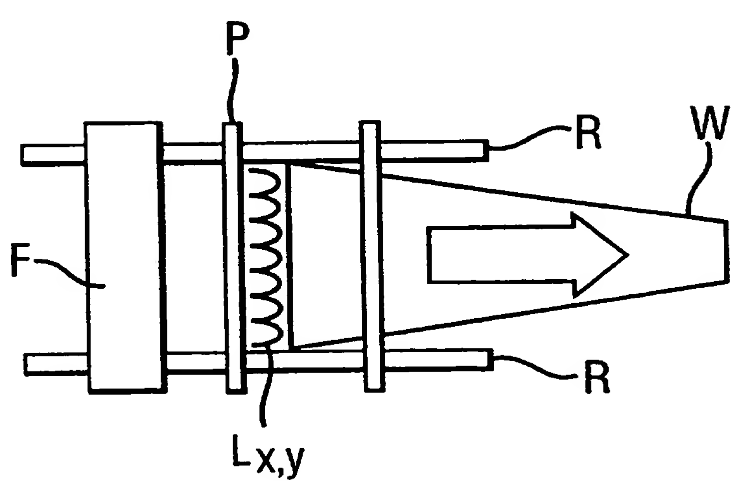


FIG. 2

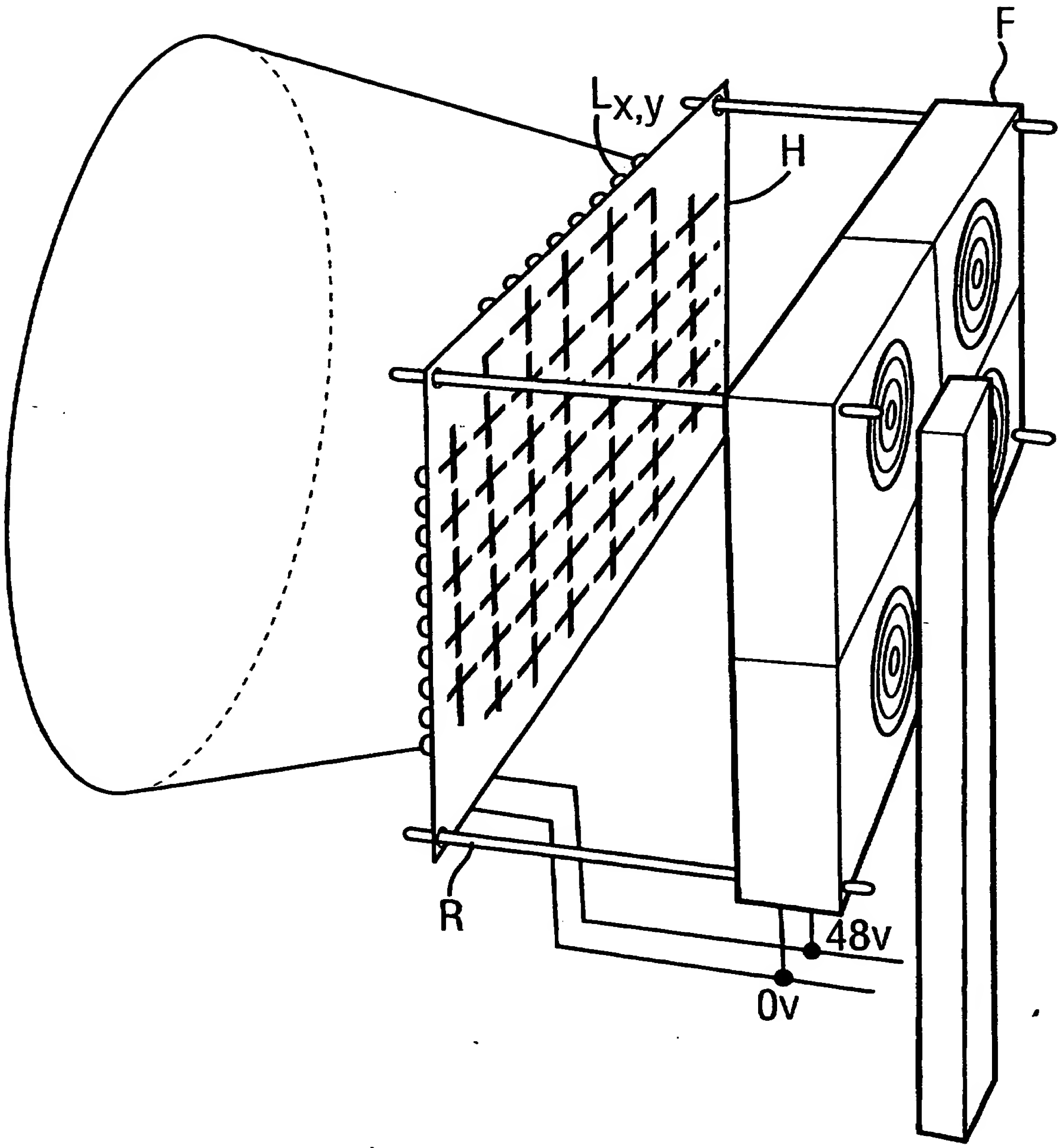


FIG. 3

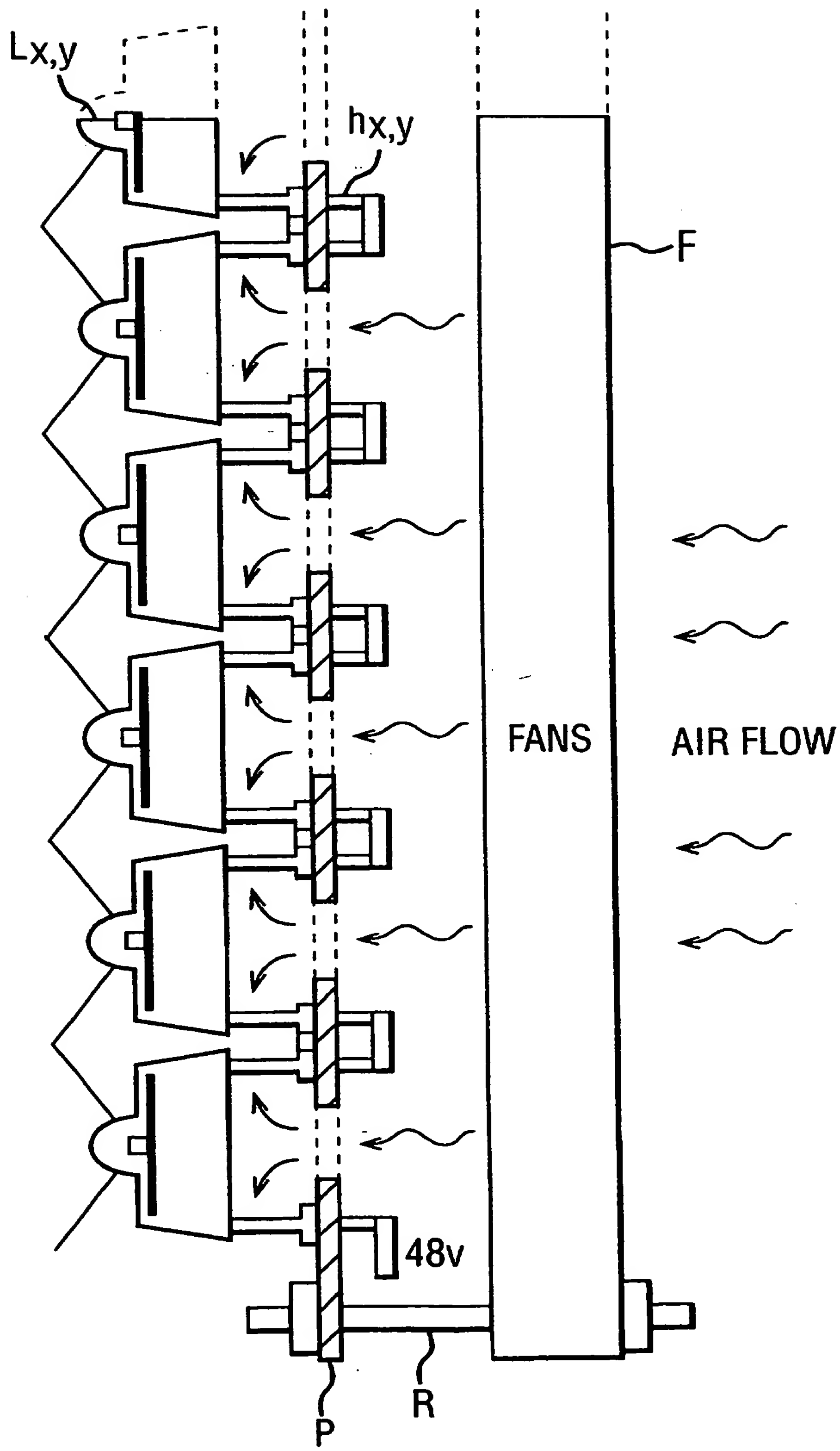


FIG. 4

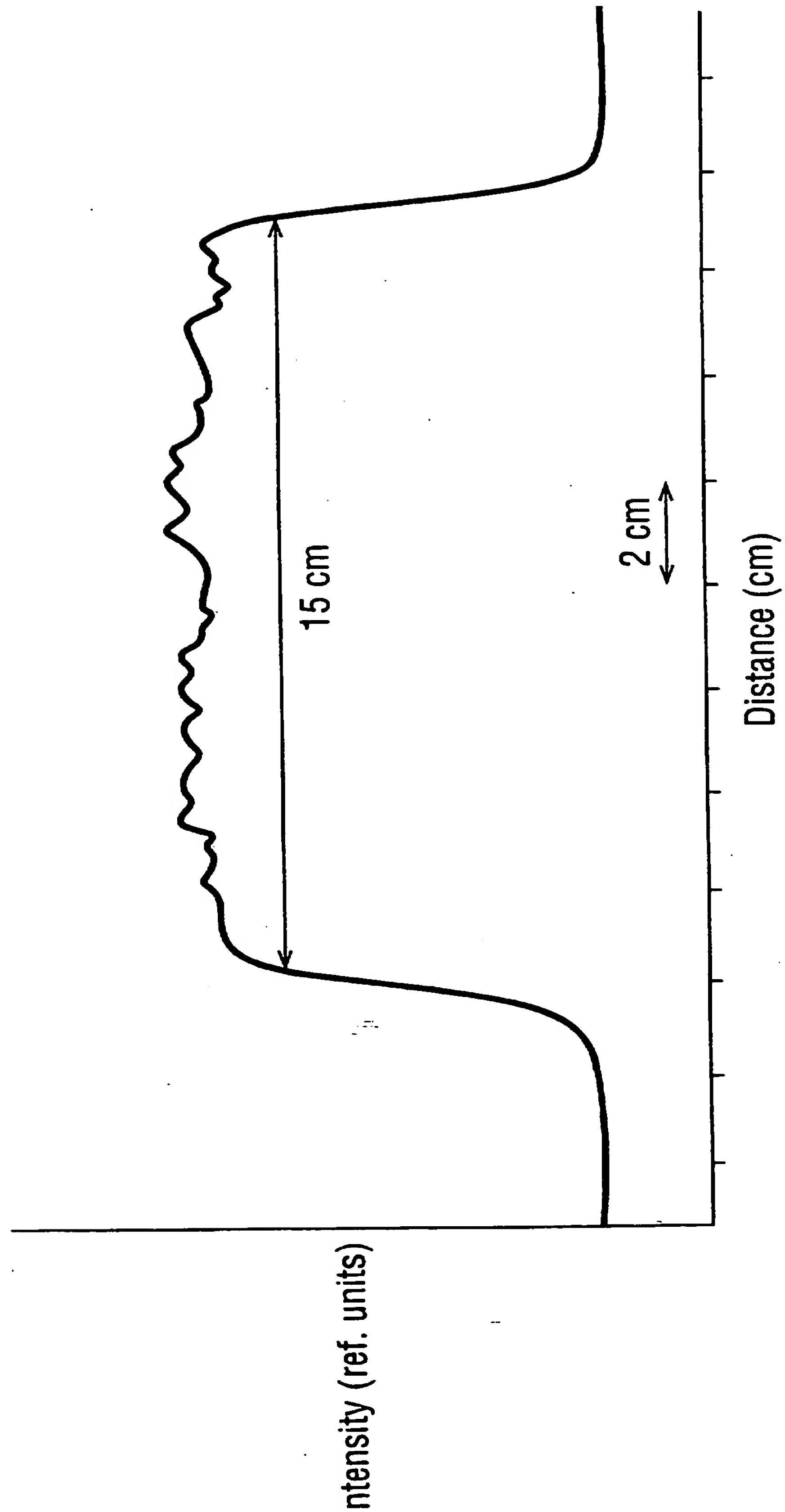


FIG. 6

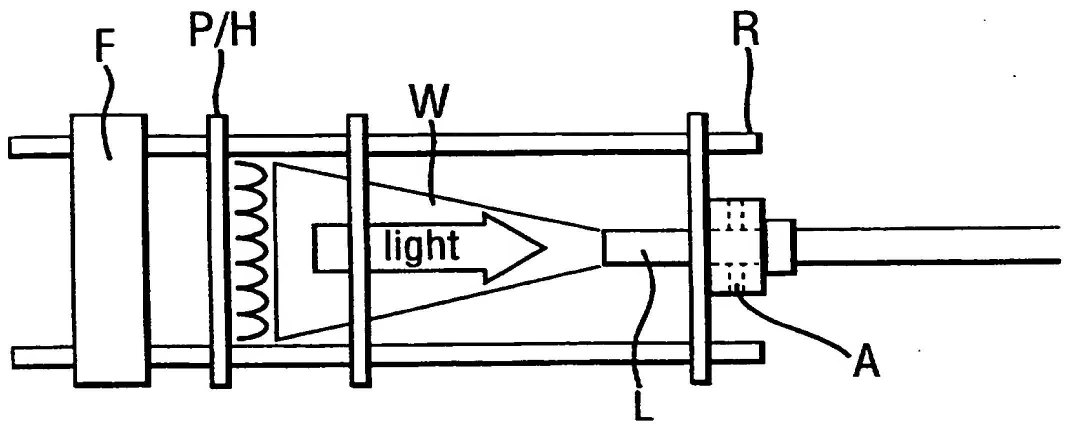


FIG. 7

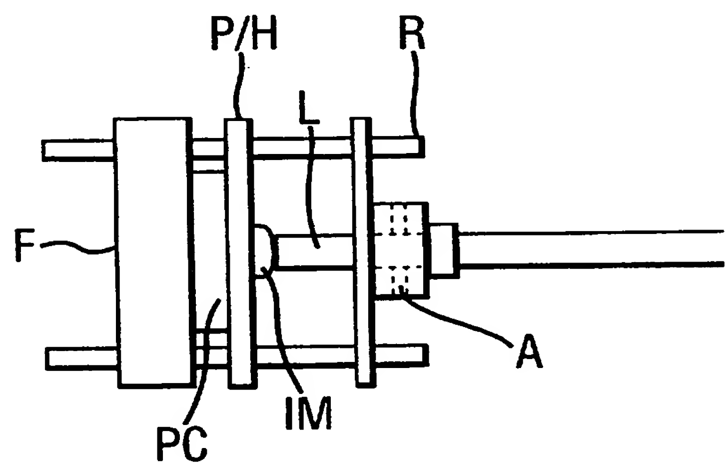


FIG. 8

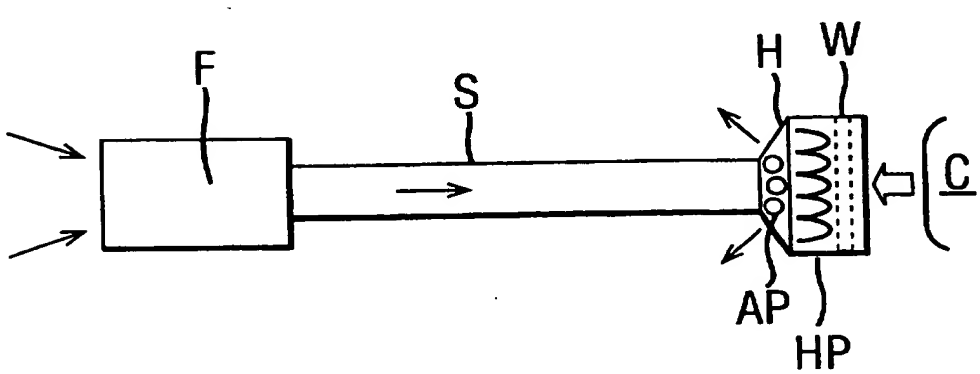


FIG. 9

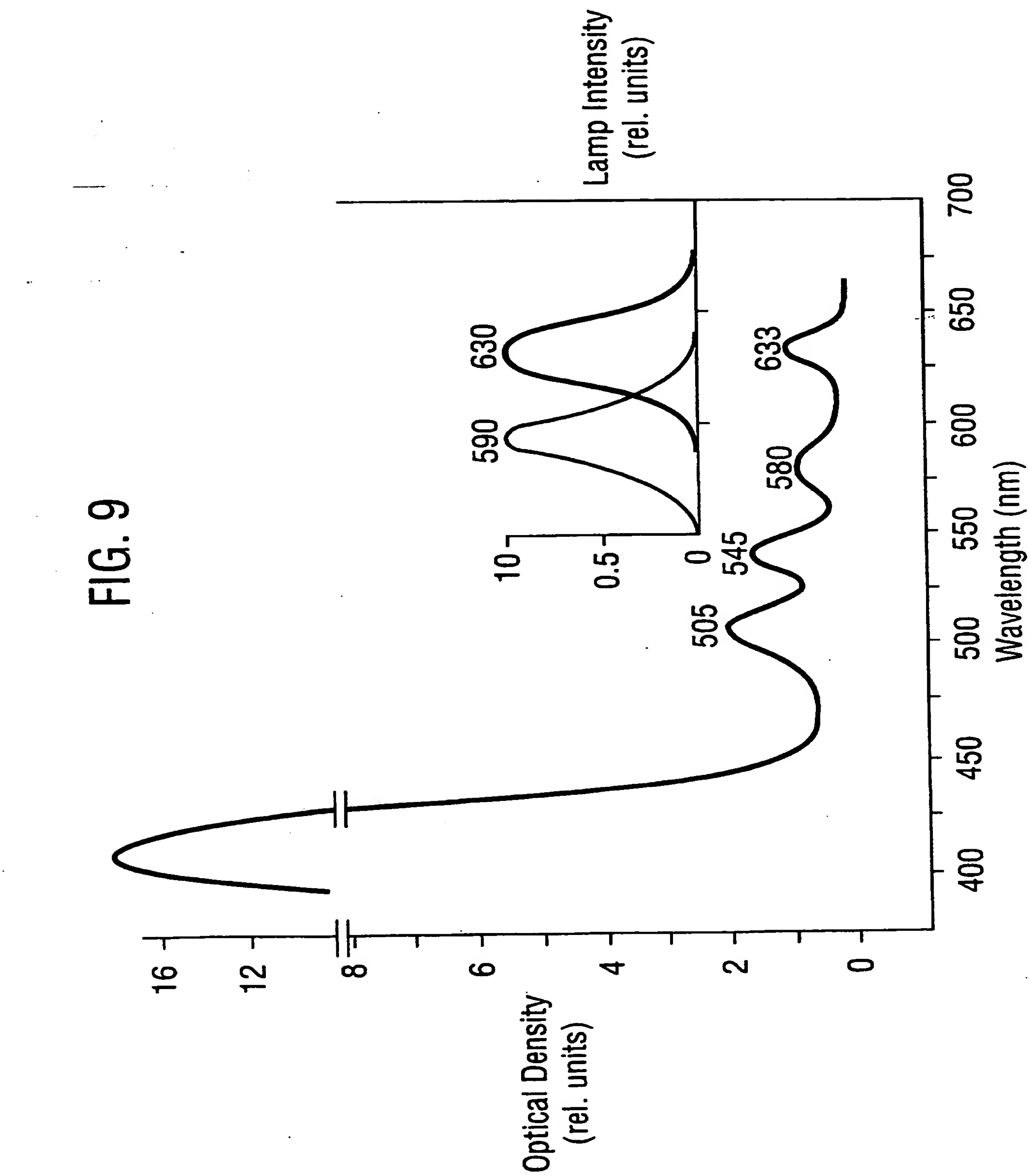

Optical Density
(rel. units)
16
12
8
6
4
2
0
Lamp Intensity
(rel. units)
1.0
0.5
0
590
630
505
545
580
633
400
450
500
550
600
650
700
Wavelength (nm)

FIG. 10a

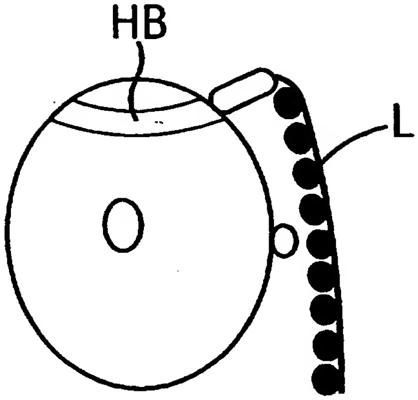


FIG. 10b

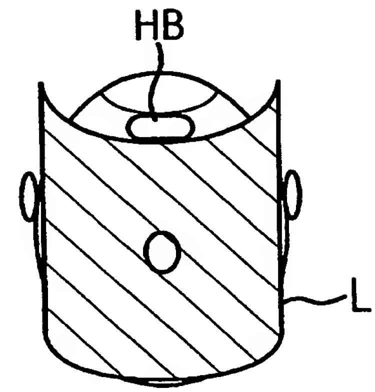


FIG. 11a

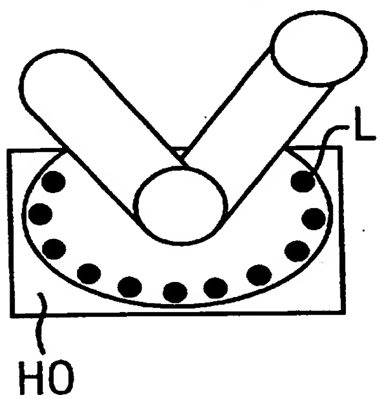


FIG. 11b

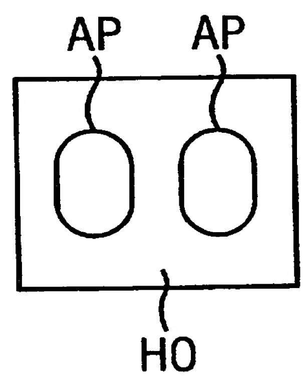


FIG. 11c

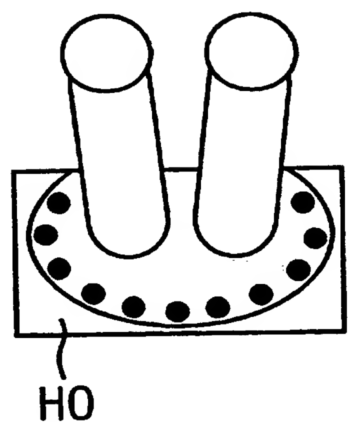


FIG. 12

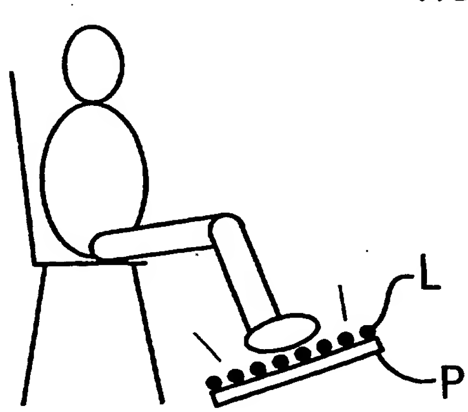


FIG. 13

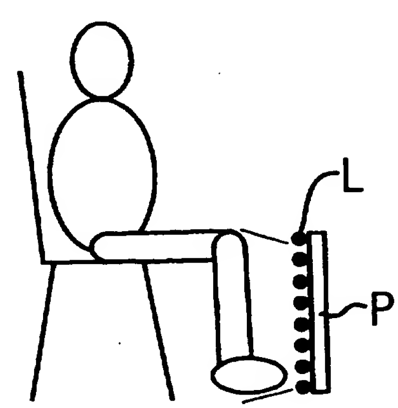


FIG. 14

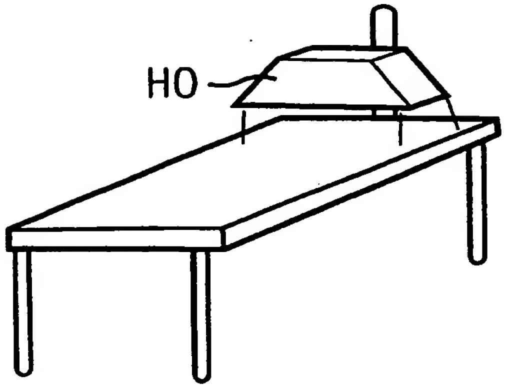


FIG. 15

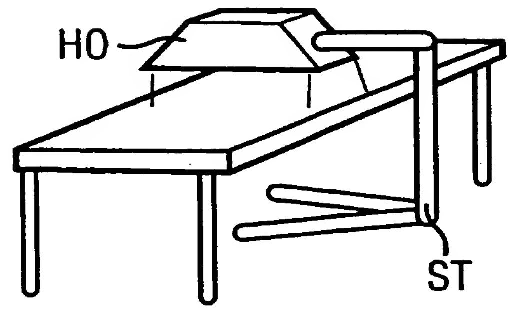


FIG. 17a

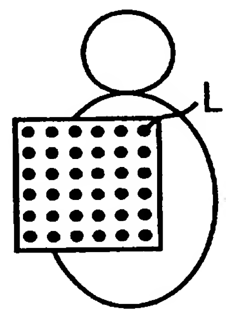


FIG. 16a

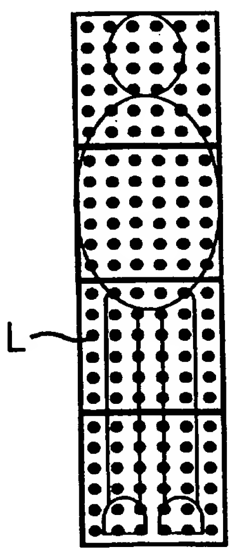


FIG. 16b

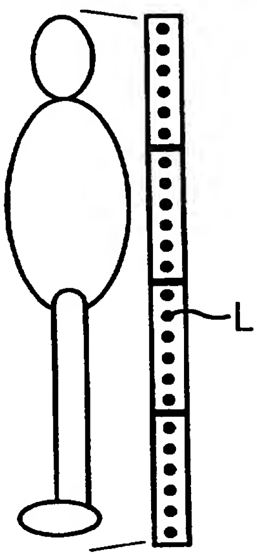


FIG. 17b

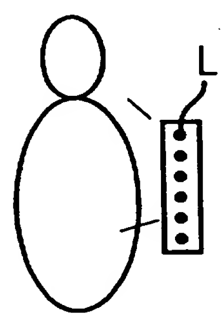


FIG. 18a

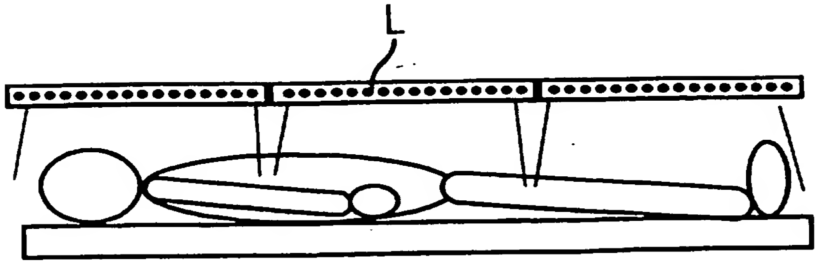


FIG. 18b

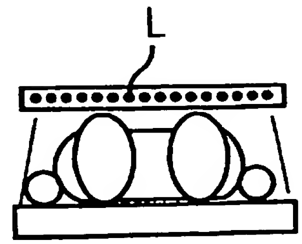


FIG. 19a

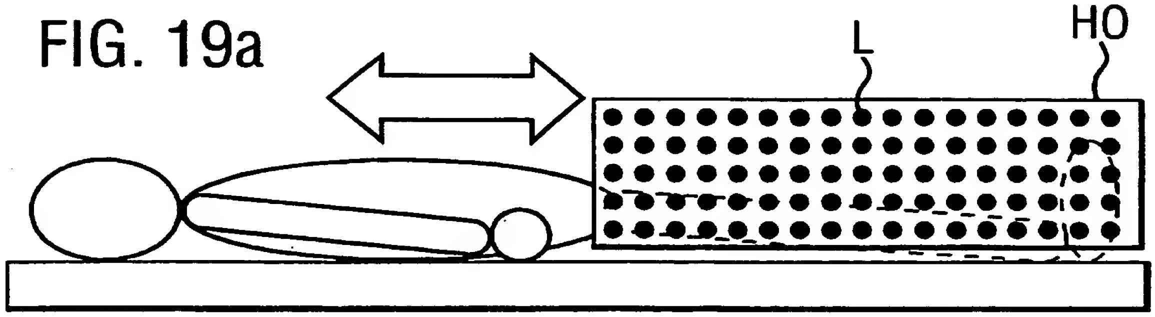


FIG. 19b

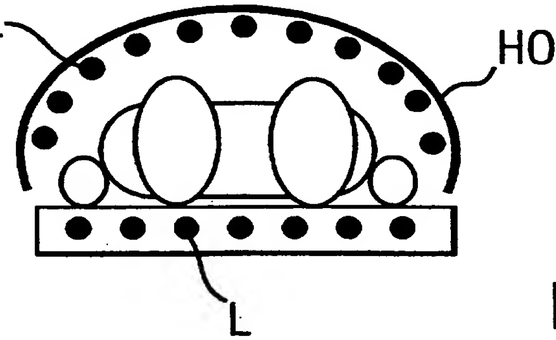


FIG. 20a

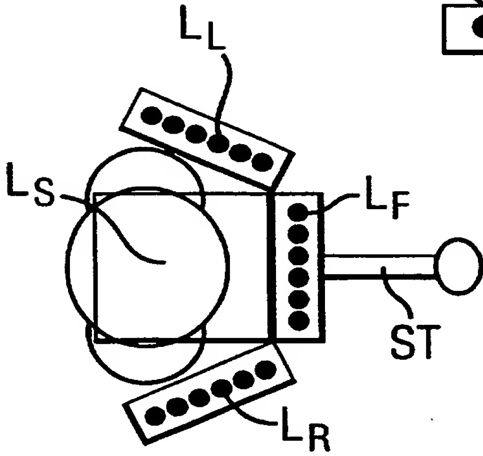
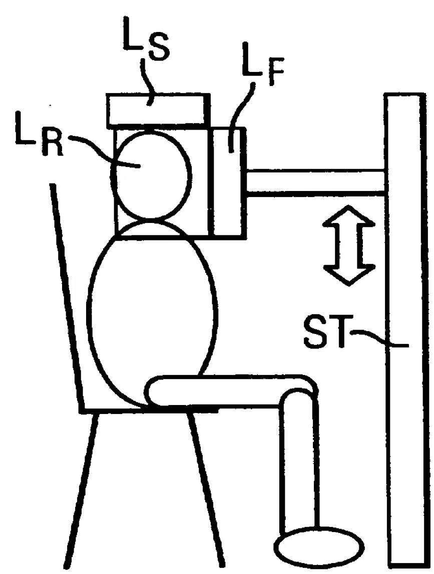


FIG. 20b



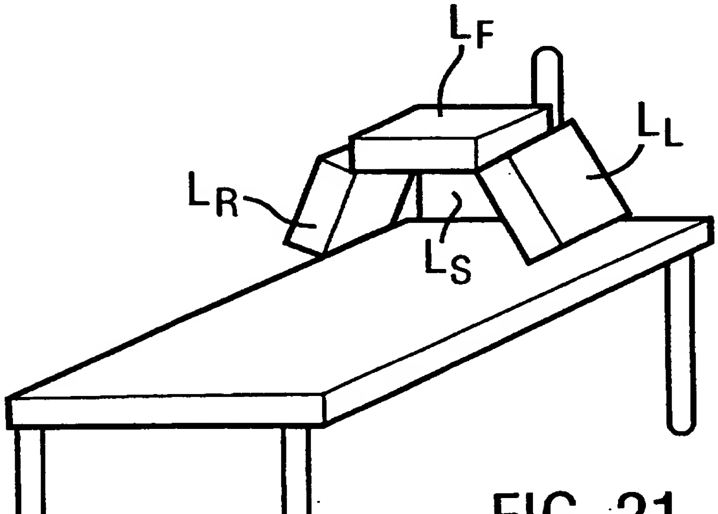


FIG. 21

FIG. 22a

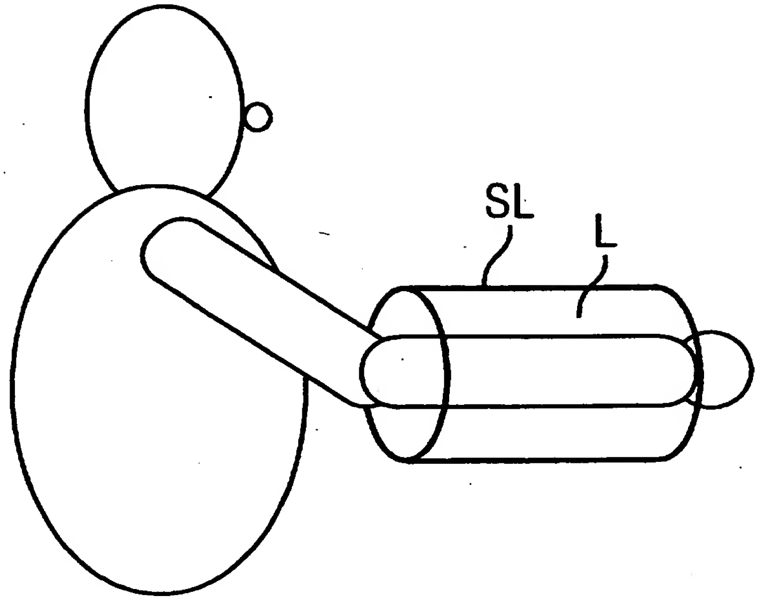


FIG. 22b

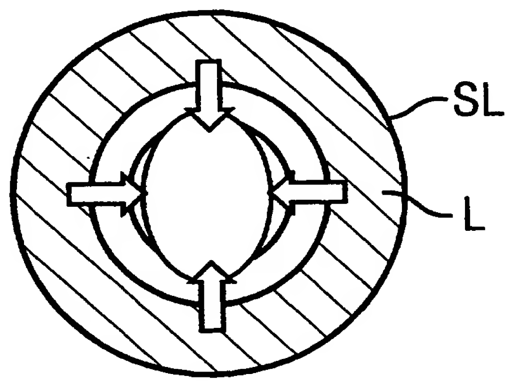


FIG. 22c

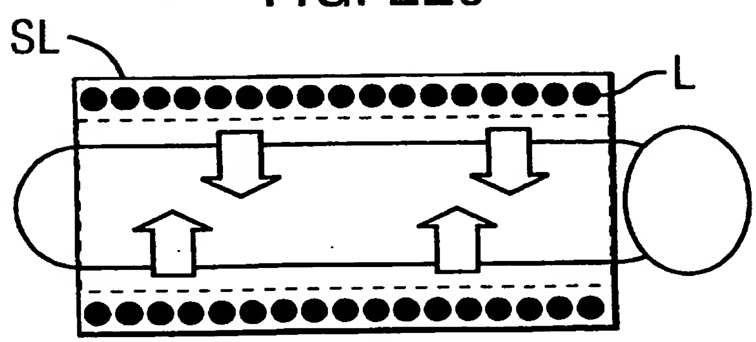


FIG. 23a

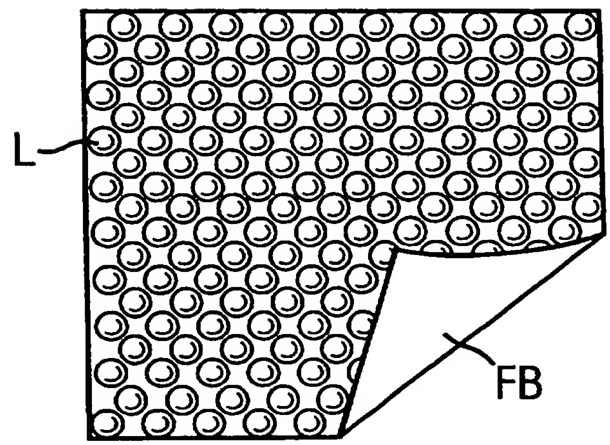


FIG. 23b

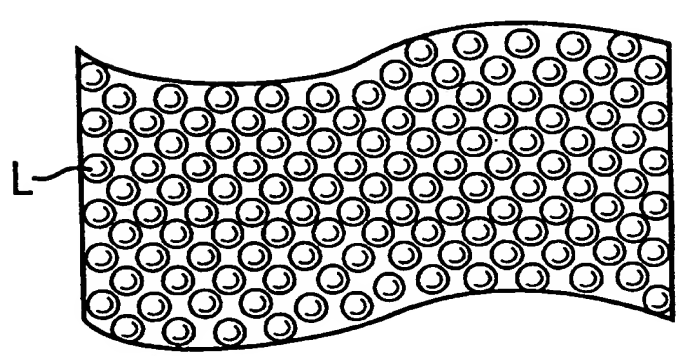


FIG. 23c

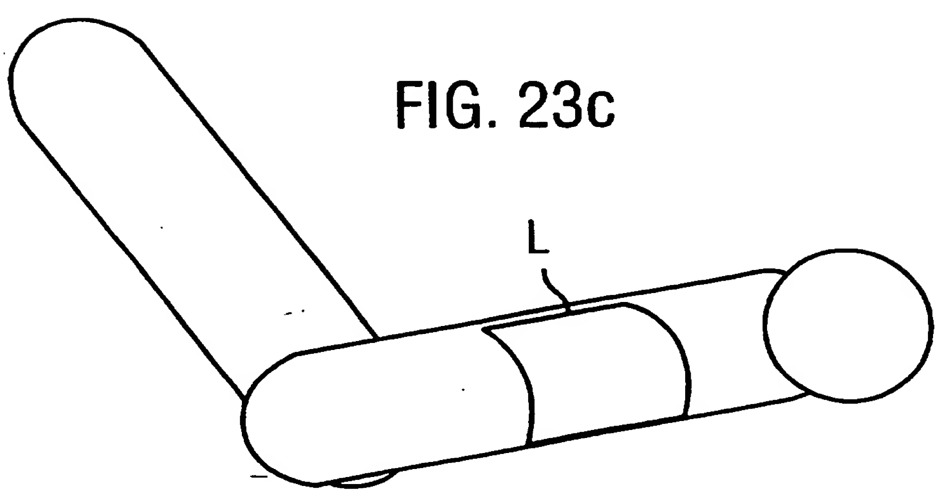


FIG. 24

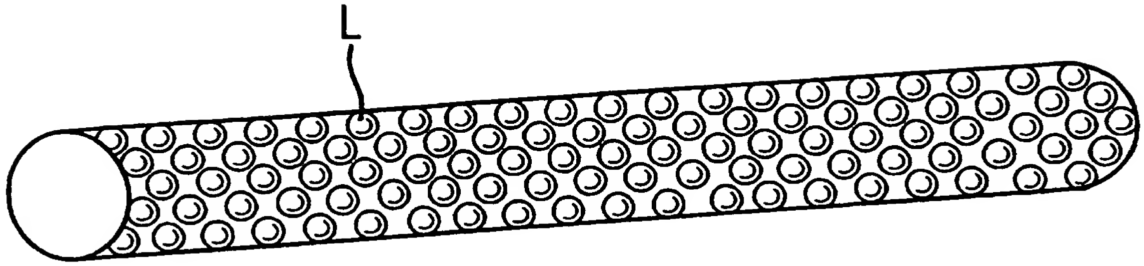


FIG. 25

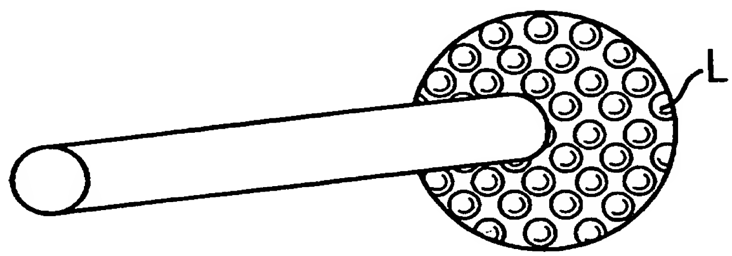
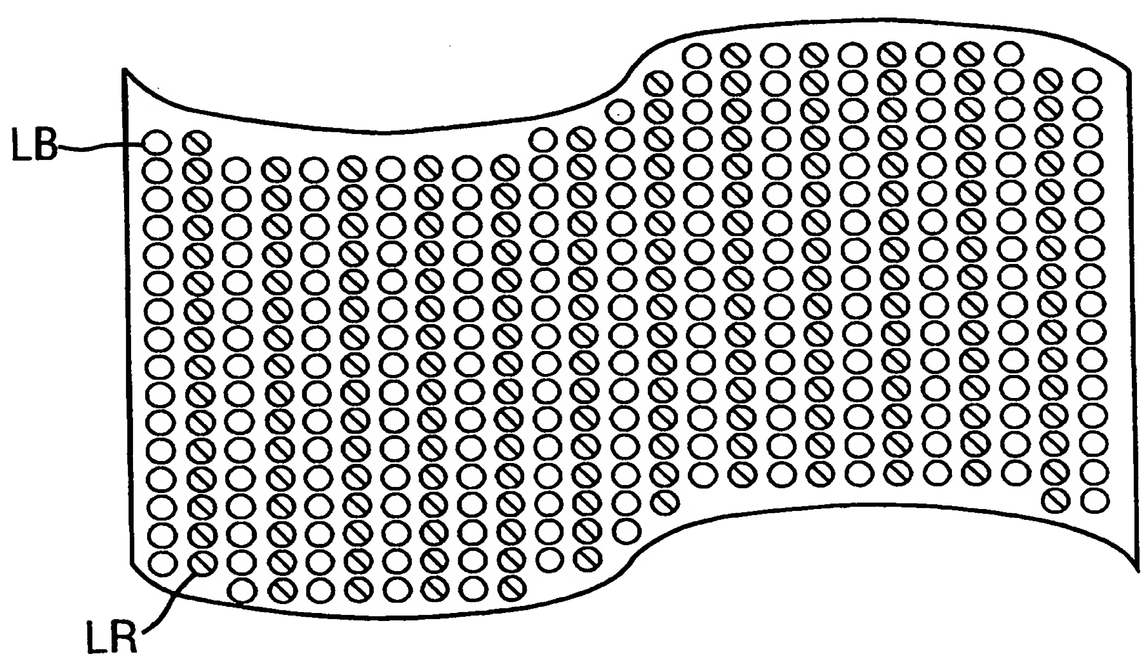


FIG. 26



THERAPEUTIC LIGHT SOURCE AND METHOD

The present invention relates to a non-coherent light source for use in therapy such as photodynamic therapy (PDT), particularly using light emitting diodes (LED's).

Photodynamic therapy involves the administration of a photosensitising drug to an affected area, and its subsequent irradiation with light - see for example 'The Physics of Photodynamic Therapy' by B C Wilson and M S Patterson, Physics in Medicine & Biology 31 (1986) April No. 4, London GB.

The document GB 2,212,010 discloses a therapeutic light source which uses an array of discrete LED's as an alternative to lasers or laser diodes. The output of the LED's is focussed so as to provide the necessary intensity.

The document WO 94/15666 discloses a therapeutic light source specifically for PDT, with an integrated array of LED's mounted on the distal end of a hand piece. The LED's are overdriven to give the necessary intensity, and cooled by the flow of water around a closed loop passing along the hand piece. The document US 5728090 discloses a somewhat similar device with various different types of head containing integrated LED matrices. These devices require complicated liquid cooling circuits which would add to the cost of the device and add to the bulk of the hand piece, which is disadvantageous for invasive use.

The document US 5728090 mentions that the wavelength of the LED's is between 300 nm and 1300 nm and is selected based upon the particular photosensitive dye used during PDT. However, the wavelengths of LED's capable of providing the necessary intensity for PDT cannot freely be chosen within that range.

According to one aspect of the present invention, there is provided a light source for therapy and/or diagnosis, comprising a non-planar array of

light-emitting diodes conforming with the shape of an external area to be treated or diagnosed.

According to another aspect of the present invention, there is provided a light source for therapy and/or diagnosis, comprising a first array of light-emitting diodes and a second array of light emitting diodes movably connected thereto.

According to another aspect of the present invention, there is provided a light source for therapy and/or diagnosis, comprising an array of light-emitting diodes mounted on the curved inner surface of a housing arranged to cover at least part of the length of a patient.

According to another aspect of the present invention, there is provided a light source for therapy or diagnosis of a patient, comprising an array of light-emitting diodes arranged within a housing, and an aperture allowing a part of the patient's body to be inserted into the housing, the array being arranged to direct light onto the part of the patient's body when inserted into the housing.

According to another aspect of the present invention, there is provided a light source for therapy or diagnosis of a patient, comprising an array of light-emitting diodes arranged within a sleeve so as to direct light onto part of an arm and/or hand of a patient when inserted into the sleeve.

According to another aspect of the present invention, there is provided a light source for therapy or diagnosis of a patient, comprising an intraluminal probe carrying on the surface thereof an array of discrete light-emitting diodes.

According to another aspect of the present invention, there is provided a therapeutic light source comprising an air-cooled array of LED's, the air being vented in the vicinity of the array. In one embodiment, the array is mounted at the distal end of a hand piece suitable for invasive therapy.

According to another aspect of the present invention, there is provided a therapeutic light source comprising an array of LED's coupled to a light

guide for delivering the light to the area to be treated. Preferably, the LED's are directly coupled without intervening optical devices.

According to another aspect of the present invention, there is provided a therapeutic light source comprising an array of LED's with emission spectra substantially limited to the range 550 to 660 nm, and preferably to one of the ranges 590 to 640 nm, 560 to 644 nm, 650 to 660 nm, and 550 to 570 nm.

According to another aspect of the present invention, there is provided a therapeutic light source comprising an array of LED's with peak emission spectra of approximately 430 nm, 470 nm, 505 nm or 525 nm.

Specific embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagram of a parallel-series matrix of discrete LED's used in first and second embodiments of the present invention;

Figure 2 is perspective diagram of the first embodiment;

Figure 3 is a cross section of part of the first embodiment;

Figure 4 is a graph showing the variation of intensity in a cross-section of the output of the first embodiment;

Figure 5 is a cross-sectional diagram of a second embodiment;

Figure 6 is a cross-sectional diagram of a third embodiment;

Figure 7 is a cross-sectional diagram of a fourth embodiment;

Figure 8 is a cross-sectional diagram of a fifth embodiment;

Figure 9 is a graph showing the absorption spectrum of PpIX and the emission spectra of two examples of LED's suitable for use with the embodiments;

Figures 10a and 10b are side and front views respectively of an LED array in a sixth embodiment for treatment of the face;

Figures 11a, 11b and 11c are a cross-section in the plane of the patient's arm, a top view and a vertical cross-section transverse to the patient's arm of an LED array in a seventh embodiment for treatment of the elbows of a patient;

Figure 12 is a side view of an LED array in an eighth embodiment used for treatment of the foot or feet;

Figure 13 is a side view of an LED array in a ninth embodiment used for treatment of the lower leg;

Figures 14 and 15 show arrangements of an LED array in tenth and eleventh embodiments for treatment of respectively the face and a section of a patient lying on a bed;

Figures 16a and 16b show respectively front and side views of a set of similar LED arrays in an twelfth embodiment for treatment of one side of a patient;

Figures 17a and 17b show respectively front and side views of an LED array in a thirteenth embodiment for treatment of a section of one side of a patient;

Figures 18a and 18b are respectively side and end views of a set of similar LED arrays in a fourteenth embodiment, for treatment of one side of a patient lying down;

Figures 19a and 19b are respectively side and end views of an LED array in a fifteenth embodiment for treatment of a section of a patient lying down;

Figures 20a and 20b are top and side views respectively of an arrangement of LED arrays in a sixteenth embodiment for treatment of the face and/or scalp;

Figure 21 shows a similar arrangement to that of Figures 20a and 20b, in a seventeenth embodiment for treatment of the face and/or scalp of a patient lying down;

Figures 22a, 22b and 22c show respectively a side view, a transverse cross-section and a longitudinal cross-section of an LED array arranged within a sleeve in a eighteenth embodiment, for treatment of the hand, forearm and/or elbow;

Figures 23a, 23b and 23c show respectively two different shapes of flexible LED array, and a flexible array applied as a patch onto the skin of a patient, in an nineteenth embodiment;

Figure 24 shows an LED array arranged on the side of a cylindrical intraluminal probe in a twentieth embodiment;

Figure 25 shows an LED array arranged on the surface of a spherical intraluminal probe in a twenty-first embodiment; and

Figure 26 shows a more specific example of the flexible LED array in the nineteenth embodiment.

In a therapeutic light source in the first embodiment, as illustrated in Figures 1 to 5, light is emitted from a parallel-series matrix of LED's L connected through a current-limiting resistor R to a source of a voltage +V. The LED matrix is mounted on a heatsink array H parallel to and spaced apart from a fan array F by support rods R. Air is blown by the fan array F onto the back of the heatsink array H.

As shown in more detail in Figure 3, the heatsink array H comprises a plurality of individual heatsinks h mounted on the ends of the legs of the LED's, which pass through a support plate P. Each leg is soldered to an adjacent leg of another of the LED's in the same column. The support plate P is perforated to allow air to flow more freely around the heatsinks h and the LED's L.

The LED's L are arranged so as to produce a substantially uniform illumination of ±10% or less across a treatment field by selecting the beam divergence and spacing of the LED's L so that their individual beams overlap without causing substantial peaks or troughs in intensity. In the example shown in Figure 4, uniformity of ±6% is achieved. In this embodiment, no optical system is needed between the LED's and the patient; instead, the light is emitted directly from the LED's onto the patient. As the light is not concentrated by any optical system, the LED's have individual power outputs of at least 5 mW and preferably at least 10 mW, to give the necessary fluence

rates in the treatment field of at least 30 mW/cm^2 in the red region of the spectrum and at least 10 mW/cm^2 in the blue region.

In one specific example, a 15 cm diameter array of 288 'Super flux' LED's was used to produce a total light output of 8 W at 45 mW/cm^2 in the treatment field. The LED's were driven at a higher current load than their specification while being cooled by forced air convection from the fans F. In the specific example, the current was limited to 90 mA per column of diodes, but may be increased to 120 mA or more if increased light output is needed. The number of diodes in series, in each column, is selected so that the total forward operating voltage is as close as possible to, but less than, the power supply output voltage, in this case 48 V. This arrangement avoids wasteful in-circuit heating and maximizes the operating efficiency of the electrical system.

A method of treatment for oncological and non-oncological skin diseases such as cases of actinic/solar keratoses, Bowen's disease, superficial basal cell carcinoma, squamous cell carcinoma, intraepithelial carcinoma, mycosis fungoides, T-cell lymphoma, acne and seborrhoea, eczema, psoriasis, nevus sebaceous, gastrointestinal conditions (e.g. Barratt's oesophagus and colorectal carcinomas), gynaecological disorders (e.g. VIN, CIN and excessive uterine bleeding), oral cancers (e.g. pre-malignant or dyplastic lesions and squamous cell carcinomas), viral infections such as herpes simplex, molluscum contagiosum, and warts (recalcitrant, verruca vulgaris or verruca plantaris), alopecia areata, or hirsutism, using the first embodiment, will now be described. A cream or solution containing a photosensitising drug such as 5-ALA is applied topically under medical supervision to the affected area of the skin of the patient, or administered intravenously or orally. In another method of application for large areas, the patient may be immersed in a bath of solution. The affected area may then be covered for a period of 3 to 6 hours, or up to 24 hours if the treatment is to be continued the next day, to prevent removal of the drug and carrier, or activation by sunlight. The area is then uncovered and exposed to light from the lamp according to the first

embodiment for a period of 15 to 30 minutes. The treatment may then be repeated as necessary, for a total of 1 to 3 treatments. This method is particularly suitable for the treatment of patients with very large lesions or multiple lesions extending over a large area.

In a method of treatment using the device of the first embodiment, the LED array is positioned approximately parallel to an external affected area of a patient to be treated, with a separation sufficient to achieve the uniform illumination as shown in Figure 4, for example 2 to 5 cm. The device may also be used for cosmetic or partially cosmetic treatment with a photosensitizing drug for portwine stain removal and hair restoration/removal, and without a photosensitizing drug for skin rejuvenation, wrinkle removal or biostimulation (including wound healing).

The lamp may also be used for fluorescence detection (photodiagnosis).

The first embodiment may be modified in a second embodiment, as shown in Figure 5, by the addition of a frusto-conical waveguide W, for example of acrylic (e.g. Perspex™) or glass, supported by the support rods R, which are extended in this embodiment. The waveguide W is arranged to concentrate light emitted by the LED's onto a smaller area with higher intensity. This arrangement is suitable for treating smaller external surfaces.

The second embodiment may be modified in a third embodiment, as shown in Figure 6, to deliver the light from the waveguide W into a lightguide L for internal treatment. The lightguide L, such as an optical fibre or fibre bundle, or liquid light guide, is held in a lightguide receptacle or adapter A, that is compatible for example with Olympus, Storz, ACMI or Wolf light cable fittings, in abutment or immediately adjacent relation with the narrow end of the waveguide W. The lightguide L may be of 3, 5 or 8 mm diameter. The support rods R align the optical axes of the waveguide W and lightguide L, so that the light emitted by the waveguide W is launched into the lightguide L. In the third embodiment, the light is concentrated by the waveguide and

emitted over a small area at the distal end of the lightguide L which may be inserted into body cavities for oral, gynaecological, gastrointestinal or intraluminal treatment.

The third embodiment may be modified in a fourth embodiment, as shown in Figure 7, in which the discrete LED array is replaced by an integrated multi-die LED matrix IM (for example part no. OD 6380, OD 6624 or OD 6680 available from AMS Optotech, Bristol, UK) mounted on the support plate/heatsink P, H. A Peltier effect thermoelectric cooler PC is mounted in thermal contact with the opposite side of the support plate P, the heated side of which is cooled by the fan F. The proximal end of the lightguide L is directly adjacent or abutting the integrated LED matrix IM, which are of similar cross-section so that the waveguide is not needed to launch the emitted light into the lightguide L.

A fifth embodiment, as shown in Figure 8, is designed specifically for treatment of the cervix, such as PDT treatment. The fifth embodiment has the form of a hand piece having a hollow stem S, for example of acrylic or polycarbonate, through which air is blown at low pressure by a fan F mounted at the proximal end. The distal end has a head portion HP comprising a housing within which is mounted a discrete LED array mounted on a support plate/heatsink P/H. Air passes through the hollow stem S onto the heatsink H so as to extract heat therefrom and is then vented through apertures AP on the proximal side of the housing. The distal end of the housing is concave and dimensioned so as to fit closely over the end of the cervix C. A transparent end window W, for example of acrylic or glass, prevents infiltration of the LED's. Power is carried to the LED's through wires (not shown) mounted on the wall of the acrylic stem S. In use, the hand piece is positioned so that the distal end fits over the cervix of the patient and is clamped in position for the duration of the treatment.

The selection of appropriate discrete LED's for PDT using any of the first to fourth embodiments will now be described, grouped according to die material.

A first suitable type of LED is based on aluminium indium gallium phosphide/gallium phosphide (AlInGaP/GaP) of transparent substrate (TS) or absorbing substrate (AS) type. The output wavelengths are in the range 590 to 640 nm with peak emission wavelengths of 590, 596, 605, 615, 626, 630 and 640 nm. Commercially available examples are the 'SunPower'™ or 'Precision Optical Power'™ series from Hewlett Packard Company, designed for use in the automotive industry, for commercial outdoor advertising and traffic management. Suitable LED's are those packaged as: SMT (surface mount technology) e.g. HSMA, HSMB, HSMC, HSML series and preferably HSMB HR00 R1T20 or HSMB HA00R1T2H; Axial e.g. HLMA or HLMT series; T1 e.g. HLMP series, preferably HLMP NG05, HLMP NG07, HLMP J105; T13/4 e.g. HLMP series, preferably HLMP DG08, HLMP DG15, HLMP GG08, HLMP DD16; Superflux™ e.g. HPWA or HPWT series, preferably HPWA (MH/DH/ML/DL) 00 00000, HPWT (RD/MD/DD/BD/RH/MH/DH/BH/RL/ML/DL/BL) 00 00000, most preferably HPWT (DD/DH/DL/MH/ML/MD) 00 00000; SnapLED™ e.g. HPWT, HPWS, HPWL series, preferably HPWT (SH/PH/SL/PL) 00, HPWT (TH/FH/TL/FL) 00 or HPWS (TH/FH/TL/FL) 00. Suitable products from other manufacturers include: of SMT type, Advanced Products Inc. (API) part no. HCL4205AO; of T1 type, American Bright Optoelectronics (ABO) part no. BL BJ3331E or BL BJ2331E; of Superflux type, ABO part no.'s BL F2J23, BL F2J33 and BL F1F33.

A second suitable type of LED is the aluminium indium gallium phosphide/gallium arsenic (AlInGaP/GaAs) type, with emission wavelengths in the range 560 to 644 nm and peak emission wavelengths of 562 nm, 574 nm, 590 nm, 612 nm, 620 nm, 623 nm and 644 nm. Examples commercially available from Toshiba in T1 package are the TLRH, TLRE, TLSH, TLOH or

TLYH series, preferably TLRH 262, TLRH 160, TLRE 160, TLSH 1100, TLOH 1100, TLYH 1100 or S4F4 2Q1; or in T13/4 package are the TLRH or TLSH series, preferably TLRH 180P or TLSH 180P. Another example is Kingbright L934SURC-E.

A third suitable type of LED is aluminium gallium arsenic type (AlGaAs), with emission wavelengths in the range 650 to 660 nm. Examples in T1 package include the Toshiba TLRA series, preferably TLRA 290P or TLRA 293P, and Kingbright L934 SRCG, L934 SRCH, and L934 SRCJ and in T13/4 package include Kingbright L53 SRCE.

A fourth suitable type of LED is gallium phosphide (GaP) type, with emission wavelengths in the range 550 to 570 nm.

A fifth suitable type of LED is indium gallium nitride (InGaN). In the type with an emission wavelength of 525 nm, commercially available examples include: in SMT package, API's HCL 1513AG; and in T1 package, Farnell's #942 467, Radio Spare's #228 1879 and #249 8752, API's HB3h 443AG and Plus Opto's NSPG500S. In the type with emission wavelengths of 470 and 505 nm and T1 package type, examples are Farnell's #142 773, Radio Spare's #235 9900 and American Bright Optoelectronics Inc.'s BL BH3PW1.

A sixth suitable type of LED is gallium nitride/silicon (GaN/Si), with an emission wavelength of 430 nm. One commercial example is Siemens LB3336 (also known as RS #284 1386).

Each of the above LED types is selected to have an emission spectrum substantially coincident with the absorption spectrum of one or more of the following common photosensitizers given below in Table 1, and therefore embodiments having such LED's are suitable for PDT. For example, Figure 9 shows the absorption spectrum of PpIX, including peaks at 505nm, 545 nm, 580 nm and 633 nm. Inset are the emission spectra, in units of peak intensity and on the same wavelength axis, of LED part no. HPWA DL00 with a peak at 590 nm and LED part no. HPWT DH00 with a peak at 630 nm, the peaks

having sufficient breadth to give a substantial overlap with the 580 nm and 633 nm peaks respectively in the absorption spectrum of PpIX.

Table 1

Photosensitizer	Red absorption Band (nm)	Red Peak (nm)	Blue/Green Peak (nm)
Naphthalocyanines	780-810		
Chalcogenopyrilium dyes	780-820		
Phthalocyanines (e.g. ZnII Pc)	670-720	690	
Tin etiopurpurin ($SnET_2$)	660-710	660-665	447
Chlorins (e.g. N-Aspartyl chlorin e6 or NPe6)	660-700	664	
Benzoporphyrin derivative (BPD)		685/690	456
Lutetium texaphrin (Lu-Tex)		735	
$Al(S_1/S_2/S_3/S_4)$ Pc	660-710	670/685	410, 480
Photofrin		625/630	405
Protoporphyrin IX (PpIX) - from 5/δAminolaevulinic Acid (5ALA)		635	410, 505, 540, 580
Tetra m-hydroxyphenyl Chlorin (mTHPC)		650	440, 525

The discrete LED array may comprise more than one different type of LED, each with different emission spectra, selected to match different absorption bands of the selected photosensitizer. Each type of LED may be switched independently. The penetration depth (i.e. the depth at which the intensity has been attenuated to e^{-1}) may also be varied by switching on only one type of LED in the array so as to select a suitable emission band, since the penetration depth is a function of the wavelength.

The LED array may be composed of individually switchable spatially distinct segments of LED's. Selected segments may be switched on so as to treat a selected area of the patient within the overall area of the matrix array.

The lamp may include an electro-optical detector arranged to monitor the light dose delivered and to switch off the light emission when a target dose is reached. Alternatively, or additionally, the detector is arranged to monitor the instantaneous light intensity and to vary the electrical power supplied to the tubes so as to maintain the intensity within predetermined limits, and/or to switch off the light emission if a maximum limit is exceeded.

Various different arrangements of LED array suitable for treatment of different areas of a patient will now be described. The LED's are discrete LED's as described above. Except where stated otherwise, the LED's may be fan-cooled using integrated fans.

Figures 10a and 10b show an array of LED's L in a sixth embodiment, arranged on a support P shaped as a curved visor for treatment of the face of a patient. The array is supported in front of the patient's face by a head band HB or other head wear worn by the patient.

Figures 11a to 11c show an array of LED's L in a seventh embodiment arranged within a cuboid housing HO which has two similar apertures AP on one face, to allow the elbows to be inserted into the housing HO. The edges of the apertures AP are cushioned to allow the arms to be rested comfortably. Within the housing HO is arranged a surface SU which is curved both in the plane of the arms and perpendicular to that plane, as shown in Figure 11c. The LED's L are mounted on this surface SU so that light emitted therefrom is concentrated onto the elbows of the patient.

Figure 12 shows an LED array L in an eighth embodiment mounted on a support plate P, and covered by a transparent or translucent cover on which the foot or feet of the patient rest during treatment.

Figure 13 shows an LED array L in a ninth embodiment mounted on a support plate P and arranged for treatment of the lower leg of a patient.

Figures 14 and 15 show an LED array L, mounted in a housing HO in the form of a trapezoid prism, the upper inner surface carrying the LED array and the lower surface being open to allow light to fall onto the patient. The side faces may be reflective, or carry additional LED arrays. In the tenth embodiment shown in Figure 14, the housing HO is mounted at one end of a bed so that its height above the bed is adjustable, for facial treatment of a patient lying on the bed. In the eleventh embodiment shown in Figure 15, the housing HO is mounted on a stand ST and is adjustable in height, for treatment of a selected part of a patient lying on the bed.

Figures 16a and 16b show a series of four coplanar LED arrays L in a twelfth embodiment arranged to treat one side of a patient. Each of the arrays is independently switchable so that selected sections of the patient can be treated.

Figures 17a and 17b show a single LED array L in a thirteenth embodiment positioned to treat a section of the patient.

Figures 18a and 18b show a series of three coplanar LED arrays L in a fourteenth embodiment arranged to treat one side of a patient lying down. Each of the arrays is independently switchable so that selected sections of the patient can be treated.

Figures 19a and 19b show an array of LED's L in a fifteenth embodiment mounted on the inner surface of a curved housing HO for treatment of a patient lying on a further, planar array of LED's, for treatment of a section of the patient from all sides. The housing HO is slidable along the length of the patient so as to treat a selected area of the patient. Sections of the planar array of LED's are switchable so as to illuminate only the selected section.

Figures 20a and 20b show a sixteenth embodiment comprising a front-facial LED array L_F for directing light onto the face of the patient from the front, a scalp LED array L_S and left and right side-facial LED arrays L_L, L_R moveably connected, for example by hinges, to the front-facial array L_F, for

directing light onto the scalp, left side of the face and right side of the face respectively. The front-facial array L_F is slideably attached to a stand ST for vertical adjustment to the head height of the patient, preferably when sitting.

Figure 21 shows a seventeenth embodiment, similar to that of Figures 20a and 20b, except that it is arranged for facial and/or scalp treatment of a patient when lying down. The stand ST is mounted on a bed, instead of being free-standing, and the arrays are rotated by 90° so as to correspond to the position of the patient's head when lying down.

Figures 22a, 22b and 22c show an eighteenth embodiment in which an LED array L is mounted on the inner surface of a sleeve SL so as to direct light onto the hand, forearm and/or elbow within the sleeve.

Figures 23a and 23b show respectively a square and a rectangular LED array L in a nineteenth embodiment mounted on a flexible backing member FB which can be applied to an area of the patient to be treated, such as part of the forearm as shown in Figure 23c, with the LED's facing inwardly. The LED array thereby follows the contours of the area to be treated. The flexible backing member FB may be cooled by a fan which is either discrete or connected thereto by a flexible membrane which is fixed around the flexible backing member FB and directs air from a fan onto the backing member, through which the air is vented.

Figure 24 shows an LED array in a twentieth embodiment arranged on the surface of a cylindrical intraluminal probe, while Figure 25 shows an LED array in a twenty-first embodiment arranged on the surface of a spherical head of an intraluminal probes. The probes are dimensioned for vulval, cervical, endometrial, bladder, gastrointestinal, oral, nasal, aural and/or bronchial treatment.

In tests performed by the inventor, the efficacy of PDT using red (approximately 630 nm) emission from LED's was established in *in-vivo* comparative studies using a sub-cutaneous mammary tumour regrowth delay assay. Using radiobiological end-points, it was shown that the solid-state

prototype efficacies were comparable to that of expensive conventional lasers for PDT (i.e. no significant difference, $p=0.21$). These results were confirmed in further clinical studies in the treatment of Bowen's disease and basal cell carcinomas where comparative complete response rates were achieved as compared to laser PDT.

Figure 26 shows a more specific example of the nineteenth embodiment, consisting of rows of blue LED's L_B interspersed with rows of red LED's L_R so as to form a discrete LED array composed of different types of LED as described above. The blue LED's L_B are switchable on and off together, independently of the red LED's L_R which are also switchable on and off together. In this way, red or blue illumination may be chosen according to the type of treatment and penetration depth required.

The blue LED's have an emission spectrum substantially (for example full width half maximum bandwidth) in the range 370 to 450 nm, and preferably 400 to 430 nm. This range is particularly suitable for the treatment of pre-cancerous conditions, in particular actinic keratoses.

The red LED's have an emission spectrum substantially (for example full width half maximum bandwidth) in the range 620 to 700 nm. This range is particularly suitable for the treatment of non-melanoma, such as basal cell or squamous cell carcinoma, or mycosis fungoides.

CLAIMS

1. A light source for therapy and/or diagnosis, comprising an array of light-emitting diodes mounted on a flexible backing, the array including light-emitting diodes of a first type having a first emission spectrum and light-emitting diodes of a second type having a second emission spectrum different from the first emission spectrum.

2. A light source according to claim 1, wherein said light-emitting diodes of the first type are independently switchable from said light-emitting diodes of the first type.

3. A light source according to claim 1 or 2, wherein said first emission spectrum is substantially in the range 370 to 450 nm.

4. A light source according to claim 3, wherein said first emission spectrum is substantially in the range 400 to 430 nm.

5. A light source according to any preceding claim, wherein said second emission spectrum is substantially in the range 620 to 700 nm.

6. Use of a light source according to any preceding claim, in the treatment of a pre-cancerous condition.

7. Use according to claim 6, wherein said pre-cancerous condition is an actinic keratosis.

8. Use of a light source according to any one of claims 1 to 5, for the treatment of a non-melanoma.

9. Use according to claim 8, wherein said non-melanoma is a basal cell or squamous cell carcinoma.

10. A light source for therapy and/or diagnosis, comprising a non-planar array of light-emitting diodes conforming with the shape of an external area of a patient to be treated or diagnosed.

11. A light source as claimed in claim 10, wherein said array is mounted on a head portion for attachment to the head of a patient.

12. A light source as claimed in claim 10, wherein said array is mounted on a flexible support for attachment to the external area.

13. A light source for therapy and/or diagnosis, comprising a first array of light-emitting diodes and a second array of light emitting diodes movably connected thereto.

14. A light source as claimed in claim 13, further including a third array of light-emitting diodes movably connected to the first array.

15. A light source as claimed in claim 14, further including a fourth array of light-emitting diodes movably connected to the first array.

16. A light source as claimed in any one of claims 13 to 15, arranged for treatment of the face and/or scalp.

17. A light source for therapy and/or diagnosis, comprising an array of light-emitting diodes mounted on the curved inner surface of a housing arranged to cover at least part of the length of a patient.

18. A light source as claimed in claim 17, further comprising an array of light-emitting diodes arranged for positioning beneath the patient.

19. A light source for therapy or diagnosis of a patient, comprising an array of light-emitting diodes arranged within a housing, and an aperture allowing a part of the patient's body to be inserted into the housing, the array being arranged to direct light onto the part of the patient's body when inserted into the housing.

20. A light source for therapy or diagnosis of a patient, comprising an array of light-emitting diodes arranged within a sleeve so as to direct light onto part of an arm and/or hand of a patient when inserted into the sleeve.

21. A light source for therapy or diagnosis of a patient, comprising an intraluminal probe carrying on a surface thereof an array of discrete light-emitting diodes.

22. A light source as claimed in claim 21, wherein said surface is substantially cylindrical.

23. A light source as claimed in claim 21, wherein said surface is substantially spherical.

24. A light source for therapy or diagnosis, comprising an array of light-emitting diodes arranged to give an output intensity of at least approximately 10 mW/cm^2 in a treatment field, and means for cooling the diodes by forced air convection.

25. A light source as claimed in claim 24, arranged so that light from the light-emitting diodes is incident directly on the treatment field with a spatial intensity fluctuation of approximately 10% or less.

26. A light source as claimed in claim 24 or 25, wherein the diodes are thermally coupled to one or more heatsinks.

27. A light source as claimed in claim 24, wherein the diodes are mounted at the distal end of a passage for carrying the air from the proximal to the distal end.

28. A light source as claimed in claim 27, including a fan mounted at the proximal end of the passage.

29. A light source as claimed in claim 27 or claim 28, wherein the distal end is dimensioned so as to be locatable proximate the cervix of a patient such that light from the diode array is incident on the cervix.

30. A light source as claimed in claim 29, wherein the distal end is concave so as to fit over the cervix.

31. A light source for therapy or diagnosis, comprising an array of light emitting diodes coupled to light guiding means for delivering light emitted by the diodes to an area to be treated.

32. A light source as claimed in claim 31, wherein at least part of the light guiding means is tapered away from the diodes.

33. A light source as claimed in claim 32, wherein the light guiding means includes a tapered part which tapers away from the diodes so as to concentrate the light emitted by the diodes into a parallel-sided light guide.

34. A light source as claimed in claim 31, wherein the light emitting diodes are integrated in the array.

35. A light source as claimed in claim 34, wherein the diodes are thermally coupled to thermoelectric cooling means.

36. A light source as claimed in claim 34 or 35, wherein the light guiding means comprises a parallel-sided light guide coupled to the integrated array.

37. A light source as claimed in claim 33 or 36, wherein the parallel-sided light guide comprises one or more optical fibres and/or liquid light guides.

38. A light source for therapy or diagnosis, comprising an array of light emitting diodes having emission wavelengths substantially within the range 550 to 660 nm.

39. A light source as claimed in claim 38, wherein the emission wavelengths are substantially within the range 590 to 640 nm.

40. A light source as claimed in claim 39, wherein the diodes are of aluminium indium gallium phosphide/gallium phosphide die material.

41. A light source as claimed in claim 38, wherein the emission wavelengths are substantially within the range 560 to 644 nm.

42. A light source as claimed in claim 41, wherein the diodes are of aluminium indium gallium phosphide/gallium arsenic die material.

43. A light source as claimed in claim 38, wherein the emission wavelengths are substantially within the range 650 to 660 nm.

44. A light source as claimed in claim 43, wherein the diodes are of aluminium gallium arsenic die material.

45. A light source as claimed in claim 38, wherein the emission wavelengths are substantially within the range 550 to 570 nm.

46. A light source as claimed in claim 45, wherein the diodes are of gallium phosphide die material.

47. A light source for therapy or diagnosis, comprising an array of LED's with peak emission spectra of approximately 470 nm, 505 nm or 525 nm.

48. A light source as claimed in claim 47, wherein the diodes are of indium gallium nitride die material.

49. A therapeutic light source comprising an array of LED's with peak emission spectra of approximately 430 nm.

50. A light source as claimed in claim 49, wherein the diodes are of gallium nitride/silicon die material.

51. A light source as claimed in any of claims 10 to 50, wherein said LED's include a first set of LED's and a second set of LED's having different emission spectra from said first set.

52. A light source for therapy or diagnosis, comprising an LED array including a first set of LED's and a second set of LED's having different emission spectra from said first set.

53. A light source as claimed in claim 52, wherein the first and second set of LED's are independently switchable.

54. A light source for therapy or diagnosis, comprising an LED array including a first set of LED's and a second, spatially distinct set of LED's independently switchable from said first set.

55. Use of a light source as claimed in any one of claims 10 to 50 except for claims 29 and 30, and claims dependent thereon, for cosmetic treatment of a patient.

56. Use as claimed in claim 55, for photodynamic treatment of the patient.

57. Use as claimed in claim 56, for portwine stain removal, or hair restoration or removal.

58. Use as claimed in claim 55, for skin rejuvenation, wrinkle removal or biostimulation.

59. Use of a light source as claimed in any one of claims 10 to 54, for medical treatment of a patient.

60. Use as claimed in claim 59, for photodynamic treatment of a patient.

61. Use as claimed in claim 60, except when dependent on claim 29 or 30, in the treatment of one or more of actinic/solar keratoses, Bowen's disease, superficial basal cell carcinoma, squamous cell carcinoma, intraepithelial carcinoma, mycosis fungoides, T-cell lymphoma, acne and seborrhoea, eczema, psoriasis, nevus sebaceous, gastrointestinal conditions (e.g. Barratt's oesophagus and colorectal carcinomas), gynaecological disorders (e.g. VIN, CIN and excessive uterine bleeding), oral cancers (e.g. pre-malignant or dyplastic lesions and squamous cell carcinomas), viral infections such as herpes simplex, molluscum contagiosum, and warts (recalcitrant, verruca vulgaris or verruca plantaris), alopecia areata, or hirsutism.

62. A light source for therapy or diagnosis substantially as herein described with reference to and/or as shown in Figures 1 to 4, or Figure 5, or Figure 6, or Figure 7, or Figure 8, or Figure 9, or Figures 10a and 10b, or Figures 11a to 11c, or Figure 12, or Figure 13, or Figure 14, or Figure 15, or Figures 16a and 16b, or Figures 17a and 17b, or Figures 18a and 18b, or Figures 19a and 19b, or Figures 20a and 20b, or Figure 21, or Figures 22a to 22c, or

Figures 23a to 23c, or Figure 24, or Figure 25, or Figure 26 of the accompanying drawings.

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Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): A5R: REHR

Int Cl (Ed.7): A61N: 5/06

Other: ONLINE: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
E,X	WO 01/14012 A	(RUSSELL) see Figures, page 5 line 24 to page 6 line 9, page 21 line 20 to page 22 line 29 and page 24 line 1 to page 25 line 12	1,2 at least
P,Y	WO 00/15296 A	(LIGHT SCIENCES) see eg Figures 5-8, page 2 line 31 to page 3 line 9 and page 8 line 3 to page 10 line 6	1-9
X	WO 99/19024 A	(VIRULITE) see Figures 13 and 14 and page 8 lines 15-20	1,2 at least
X	WO 98/43703 A	(PRESCOTT) see especially page 5 lines 16-26, page 9 lines 16-26 and page 18 lines 4-25	1,2 at least
Y	EP 0266038 A	(KUREHA) see photodiodes 3a,3b in Figures 1-3 and page 3 lines 32-40	1,3-5
X	US 5616140	(PRESCOTT) see parts 20,22,702,802 in the Figures, column 5 lines 1-10 and 54-62 and column 14 line 64 to page 15 line 9	1,2,5-9 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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